JOURNAL AND PROCEEDINGS

OF THE

ROYAL SOCIETY

OF

NEW SOUTH WALES,

FOR

1907.

VOL. XLI.

EDITED BY

THE HONORARY SECRETARIES.

THE AUTHORS OF PAPERS ARE ALONE RESPONSIBLE FOR THE OPINIONS EXPRESSED THEREIN.

PUBLISHED BY THE SOCIETY, 5 ELIZABETH STREET NORTH, SYDNEY.
LONDON AGENTS:
GEORGE ROBERTSON & Co., PROPRIETARY LIMITED,
17 WARWICK SQUARE, PATERNOSTER ROW, LONDON, E.C.

1908.

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NOTICE.

The Royal Society of New South Wales originated in 1821 as the "Philosophical Society of Australasia"; after an interval of inactivity, it was resuscitated in 1850, under the name of the "Australian Philosophical Society," by which title it was known until 1856, when the name was changed to the "Philosophical Society of New South Wales"; in 1866, by the sanction of Her Most Gracious Majesty the Queen, it assumed its present title, and was incorporated by Act of the Parliament of New South Wales in 1881.

TO AUTHORS.

Authors of papers desiring illustrations are advised to consult the editors (Honorary Secretaries) before preparing their drawings. Unless otherwise specially permitted, such drawings should be carefully executed to a large scale on smooth white Bristol board in intensely black Indian ink, so as to admit of the blocks being prepared directly therefrom, in a form suitable for photographic "process." The size of a full page plate in the Journal is 4¼ in. x 6¾ in. The cost of all original drawings, and of colouring plates must be borne by Authors.

ERRATA.

Page 78, line 25, for "Ippai," read 'Kumbo.'
Page 79, Table V, seventh column, top line, for "Ippai" read "Kumbo."
Page 79, Table V, first column, line 8, for "Kumbo" read "Kubbi"
Page 79, Table V, first column, line 13, for "Ippai" read "Kumbo."
Page 104, line 12 from top, instead of "rate of hydrostatic head," etc., read "rate of loss of hydrostatic head."
Page 151, Table B, for "Pananka" (Paiarola's father) read "Knuraia."
Same Table, line 15, for "Mnuraia," read "Knuraia."

PUBLICATIONS.

The following publications of the Society, if in print, can be obtained at the Society's House in Elizabeth-street:—

Transactions of the Philosophical Society, N.S.W., 1862-5, pp. 374, out of print.

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Royal Society of New South Wales.

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HIS EXCELLENCY ADMIRAL SIR HARRY HOLDSWORTH RAWSON, K.C.B.
Governor of the State of New South Wales.

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Prof. WARREN, M. Inst. C.E., Wh.Sc.

Assistant Secretary:

W. H. WEBB.

FORM OF BEQUEST.

I bequeath the sum of £ to the ROYAL SOCIETY OF NEW SOUTH WALES, Incorporated by Act of the Parliament of New South Wales in 1881, and I declare that the receipt of the Treasurer for the time being of the said Corporation shall be an effectual discharge for the said Bequest, which I direct to be paid within calendar months after my decease, without any reduction whatsoever, whether on account of Legacy Duty thereon or otherwise, out of such part of my estate as may be lawfully applied for that purpose.

[*Those persons who feel disposed to benefit the Royal Society of New South Wales by Legacies, are recommended to instruct their Solicitors to adopt the above Form of Bequest.*]

NOTICE.

Members are particularly requested to communicate any change of address to the Hon. Secretaries, for which purpose this slip is inserted.

Corrected Address:

Name..

....

Titles, &c..

....

Address..

....

....

Date..........................

To the

Hon. Secretaries,

The Royal Society of N. S. Wales,

5 Elizabeth Street, Sydney.

LIST OF THE MEMBERS

OF THE

Royal Society of New South Wales.

P Members who have contributed papers which have been published in the Society's Transactions or Journal; papers published in the Transactions of the Philosophical Society are also included. The numerals indicate the number of such contributions.

‡ Life Members.

Elected.		
1877	P 5	Abbott, W. E., 'Abbotsford, Wingen.
1895		Adams, J. H. M., Broughton Cottage, St. James' Rd., Waverley.
1904		Adams, William John, M. I. Mech. E., 163 Clarence-street.
1906		Adams, Walter E., Assistant Engineer, Sydney Harbour Trust, Circular Quay.
1890	P 2	Allan, Percy, M. Inst. C.E., Assoc. Am. Soc. C.E., Public Works Department, Sydney.
1898		Alexander, Frank Lee, c/o Messrs. Goodlet and Smith Ld., Cement Works, Granville.
1905		Anderson, Charles, M.A., B. Sc., *Edin.*, 'Waratah,' Lower Ocean-street, Double Bay.
1903		Arnot, Arthur James, Assoc. M. Inst. C.E., M. I. Mech. E., M.I.E.E., Electrical Engineer, 83 Pitt-street.
1902		Arnott, John M., 'Strathfield,' Strathfield.
1899	P 1	Atkinson, A. A., Chief Inspector of Collieries, Department of Mines, Sydney.
1878		Backhouse, Alfred P., M.A., District Court Judge, 'Melita,' Elizabeth Bay.
1894	P 12	Baker, Richard Thomas, F.L.S., Curator, Technological Museum.
1900		Bale, Ernest, C.E., Rockhampton.
1894		‡Balsille, George, 'Lauderdale,' N.E. Valley, Dunedin, N.Z.
1896		Barff, H. E., M.A., Registrar, Sydney University.
1895	P 9	Barraclough, S. Henry, B.E., M.M.E., Assoc. M. Inst. C.E., M. I. Mech. E. Memb. Soc. Promotion Eng. Education; Memb. Internat. Assoc. Testing Materials; Lecturer in Mechanical Engineering, Sydney University; p.r. 'Marmion,' Victoria-street, Lewisham.
1906		Basnett, Nathaniel James, Accountant, 'Loorose,' Punch-st., Mosman.
1894		Baxter, William Howe, Chief Surveyor, Existing Lines Office, Railway Department, Bridge-street.
1877		Belfield, Algernon H., 'Eversleigh,' Dumaresq.
1876		Benbow, Clement A., 48 College-street.
1900		Bender, Ferdinand, Accountant and Auditor, 21 Elizabeth-street, North.
1905		Bignold, Hugh Baron, Barrister-at-Law, Chambers, Wentworth Court, 64 Elizabeth-street.
1906		Binnie, Herbert, 524 Kent-st.; p.r. 'Seabright,' Woollahra Pt.

Elected		
1901		Birks, Lawrence, B. Sc., Assoc. M. Inst. C.E., A.M.I.C.E., F.G.S., City Electrical Engineer, Christchurch, New Zealand.
1905		Blakemore, George Henry, General Manager, Great Cobar Limited, Cobar.
1888		‡Blaxland, Walter, F.R.C.S. *Eng*, L.R.C.P. *Lond.*, Fremantle, West Australia.
1893		Blomfield, Charles E., B.C.E. *Melb.*, 'Woombi,' Kangaroo Camp, Guyra.
1898		Blunno, Michele, Licentiate in Science (Rome), Government Viticultural Expert, Department of Agriculture, Sydney.
1905		Board, Peter, M.A. *Syd.*, Under Secretary and Director of Education, Department of Public Instruction, Sydney.
1907		Bogenrieder, Charles, Mining and Consulting Engineer, 151 Victoria-street, Darlinghurst.
1879		‡Bond, Albert, 131 Bell's Chambers, Pitt-street.
1904		Bosch, Ernest, Consulting Optician, Mutual Life Building, Martin Place.
1891		Bowman, Archer S., B.E., 'Keadue,' Elizabeth Bay Road.
1893		Bowman, John, Assoc. M. Inst. C.E., c/o T. A. Kemmis, Esq., 168 Phillip-street.
1907		Boyd, Robert James, M.E., Assoc. M. Inst. C.E., Fitzroy-st., Burwood.
1876		Brady, Andrew John, Lic. K. & Q. Coll. Phys. *Irel.*, Lic. R. Coll. Sur. *Irel.*, 3 Lyons Terrace, Hyde Park.
1891		Brennand, Henry J. W., B.A., M.B., Ch. M. *Syd.*, F.R.A.S., F.G.S., 231 Macquarie-street.
1902		Brereton, Victor Le Gay, Solicitor, Royal Chambers, Hunter-street; p.r. 'Osgathorpe,' Gladesville.
1878		‡Brooks, Joseph, F.R.A.S., F.R.G.S., 'Hope Bank,' Nelson-street, Woollahra.
1876		Brown, Henry Joseph, Solicitor, Newcastle.
1906		Brown, James B., Resident Master, Technical School, Granville; p.r. 'Kingston,' Merrylands.
1903		Bruck, Ludwig, Medical Publisher, 15 Castlereagh-street.
1898		‡Burfitt, W. Fitzmaurice, B.A., B. Sc., M.B., Ch. M. *Syd.*, 311 Glebe Road, Glebe Point.
1890		Burne, Dr. Alfred, Dentist, 1 Lyons Terrace, Liverpool-street.
1907		Burrows, Thomas Edward, M. Inst. C.E., L.S., Metropolitan Engineer, Public Works Department; p.r. 'Balboa,' Fern-street, Randwick.
1880		Bush, Thomas James, M. Inst. C.E., Australian Gas-Light Company, 153 Kent-street.
1904		Cambage, Richard Hind, F.L.S., Chief Mining Surveyor, p.r. Park Road, Burwood.
1904		Cameron, John Mindoro, Assoc. M. Inst. C.E., Public Works, Dept.
1907		Campbell, Alfred W., Medical Practitioner, 183 Macquarie-st.
1900		Canty, M., 'Rosemont,' 13 York-street, Wynyard Square.
1876		Cape, Alfred J., M.A. *Syd.*, 'Karoola,' Edgecliffe Rd., Edgecliffe.
1897	P 4	Cardew, John Haydon, Assoc. M. Inst. C.E., L.S., 75 Pitt-street.
1901		Card, George William, A.R.S.M., F.G.S., Curator and Mineralogist to the Geological Survey, N.S.W., Department of Mines.
1891		Carment, David, F.I.A. *Grt. Brit. & Irel.*, F.F.A. *Scot.*, Australian Mutual Provident Society, 87 Pitt-st. *Hon. Treasurer.*

Elected		
1903		Carslaw, H. S., M.A., D. Sc., Professor of Mathematics, Sydney University, Glebe.
1879	P 1	‡Chard, J. S., Licensed Surveyor, Armidale.
1885		Chisholm, William, M.D. *Lond.*, 139 Macquarie-street, North.
1907		Cobham, Allan Blenman, 'Garthowen,' Myahgah-rd., Mosman.
1896	P 2	Cook, W. E., M.C.E. *Melb.*, M. Inst. C.E.; Water and Sewerage Board, North Sydney.
1904	P 2	Cooksey, Thomas, Ph. D., B. Sc. *Lond.*, F.I.C., Second Government Analyst; p.r. 'Clissold,' Calypso Avenue, Mosman.
1876		Codrington, John Frederick, M.R.C.S. *Eng.*, L.R.C.P. *Lond.*, L.R.C.P. *Edin.*, 'Wynwood,' Wahroonga.
1906		Colley, David John K., Superintendent Royal Mint, Sydney.
1876		Colyer, J. U. C., 'Malvern,' Collingwood and Seymour-streets, Drummoyne.
1882		Cornwell, Samuel, Australian Brewery, Bourke-st., Waterloo.
1892	P 1	Cowdery, George R., Assoc. M. Inst. C.E., 'Glencoe,' Torrington Road, Strathfield.
1886		Crago, W. H., M.R.C.S. *Eng.*, L.R.C.P. *Lond.*, 16 College-street, Hyde Park.
1905		Dampney, Gerald F., Fellow of the Society of Chemical Industry, 'Doonbah,' Hunter's Hill.
1875		Dangar, Fred. H., c/o Messrs. Dangar, Gedye, & Co., Mercantile Bank Chambers, Margaret-street.
1890		Dare, Henry Harvey, M.E., Assoc. M. Inst. C.E., Public Works, Department.
1876	P 3	Darley, Cecil West, M. Inst. C.E., Australian Club, Sydney.
1877		Darley, The Right Hon, Sir Frederick, P.C., G.C.M.G., B.A., Chief Justice, Supreme Court.
1886	P 18	David, T.W. Edgeworth, B.A., F.G.S., F.R.S,, Professor of Geology and Physical Geography, Sydney University, Glebe. *Vice-President.*
1892	P 1	Davis, Joseph, M. Inst. C.E., London.
1907		Davys, Hubert John, c/o Messrs. Crossley Bros., 37 Wynyard Square; p.r. 'La Bohéme,' Marshall-st., Manly.
1885	P 2	Deane, Henry, M.A., M. Inst. C.E.. Equitable Building, George-st.; p.r. 'Blanerne,' Wybalena Road, Hunter's Hill. *President.*
1877		Deck, John Feild, M.D. Univ. *St. Andrews*, L.R.C.P. *Lond.*, M.R.C.S. *Eng.*, 203 Macquarie-st.; p.r. 92 Elizabeth-st., Ashfield.
1899	P 1	De Coque, J. V., c/o Messrs. Gibbs, Bright & Co., 37 Pitt-st.
1894		Dick, James Adam, B.A. *Syd.*, M.B., C.M. *Edin.*, 'Catfoss,' Belmore Road, Randwick.
1875	P 12	Dixon, W. A., F.C.S., Fellow of the Institute of Chemistry of Great Britain and Ireland, 97 Pitt-street.
1880		Dixson, Thomas Storie, M.B. *Edin.*, Mast. Surg. *Edin.*, 151 Macquarie-street.
1906		Dixson, William, 'Abergeldie,' Summer Hill.
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1873	P 2	Du Faur, E., F.R.G.S., 'Flowton,' Turramurra.

Elected		
1906		Epps, William, Secretary, Royal Prince Alfred Hospital, Camperdown, Sydney.
1879	P 4	Etheridge, Robert, Junr., J.P., Curator, Australian Museum; p.r. 'Inglewood,' Colo Vale,' N.S.W.
1876		Evans, George, Fitz Evan Chambers, Castlereagh-street.
1904		Evans, James W., Chief Inspector, Weights and Measures; p.r. 'Glenthorne,' 4 Railway-street, Petersham.
1877		‡Fairfax, Edward Ross, *S. M. Herald* Office, Hunter-street.
1896		Fairfax, Geoffrey E., *S. M. Herald* Office, Hunter-street.
1868		Fairfax, Sir James R., Knt., *S. M. Herald* Office, Hunter-st.
1887		Faithfull, R. L., M.D., *New York* (Coll. Phys. & Surg.), L.R.C.P. L.S.A. *Lond.*, 18 Wylde-street.
1902		Faithfull, William Percy, Barrister-at-Law, Australian Club.
1881		Fiaschi, Thos., M.D., M. Ch. *Pisa*, 149 Macquarie-street.
1888		Fitzhardinge, Grantly Hyde, M.A. *Syd.*, District Court Judge, 'Red Hill,' Beecroft, Northern Line.
1900		‡Flashman, James Froude, M.D. *Syd.*, Jersey Road, Burwood.
1902		Fleming, Edward G., A.M.I.E.E., 16 O'Connell-street.
1879		‡Foreman, Joseph, M.R.C.S. *Eng.*, L.R.C.P. *Edin*, 141 Macquarie-st.
1881		Foster, The Hon W. J., K.C., 'Thurnby,' 35 Enmore Road, Newtown.
1905		Foy, Mark, 'Eumemering,' Bellevue Hill, Woollahra.
1904		Fraser, James, M. Inst. C.E., Engineer-in-Chief for Existing Lines, Bridge-street; p.r. 'Arnprior,' Neutral Bay.
1907		Freeman, William, c/o W. A. Freeman, Challis House, Martin Place.
1899		French, J. Russell, General Manager, Bank of New South Wales, George-street.
1881		Furber, T. F., F.R.A.S., 'Wavertree,' Kurraba Road, Neutral Bay.
1899		Garran, R. R., M.A., C.M.G., Commonwealth Offices, Spring-st., Melbourne.
1876		George, W. R., 318 George-street.
1879		Gerard, Francis, 'The Grange,' Monteagle, near Young.
1859		Goodlet, J. H., 'Canterbury House,' Ashfield.
1906		Gosche, Vesey Richard, Consul for Nicaragua, 15 Grosvenor-st.
1906		Gosche, W. A. Hamilton, Electrical Engineer, 40 - 42 Clarence-street.
1897		Gould, Senator, The Hon. Albert John, 'Eynesbury,' Edgecliffe
1907		Green, W. J., Chairman, Hetton Coal Co., Athenæum Club.
1899		Greig-Smith, R., D. Sc. *Edin.*, M. Sc. *Dun.*, Macleay Bacteriologist, Linnean Society's House. Ithaca Road, Elizabeth Bay.
1891	P 1	Grimshaw, James Walter, M. Inst. C.E., M. I. Mech. E., &c., c/o W. Tarleton, 93 Pitt-street.
1899	P 2	Gummow, Frank M., M.C.E., Vickery's Chambers, 82 Pitt-st.
1891	P 12	Guthrie, Frederick B., F.I.C., F.C.S., Chemist, Department of Agriculture, 136 George-street, Sydney. *Hon. Secretary.*

Elected		
1880	P 2	Halligan, Gerald H., F.G.S., 'Riversleigh,' Hunter's Hill.
1899		Halloran, Aubrey, B.A., LL.B., Savings Bank Chambers, Moore-street.
1892		Halloran, Henry Ferdinand, L.S., 82 Pitt-street.
1887	P 7	Hamlet, William M., F.I.C., F.C.S., Member of the Society of Public Analysts; Government Analyst, Health Department, Macquarie-street, North.
1905	P 1	Harker, George, D. Sc., 35 Boulevarde, Petersham.
1881		‡Harris, John, 'Bulwarra,' Jones-street, Ultimo.
1887	P 20	‡Hargrave, Lawrence, Wunulla Road, Woollahra Point.
1884	P 1	Haswell, William Aitcheson, M.A., D. Sc., F.R.S., Professor of Zoology and Comparative Anatomy, University, Sydney; p.r. 'Mimihau,' Woollahra Point.
1900		Hawkins, W. E., Solicitor, 88 Pitt-street.
1890	P 2	Haycroft, James Isaac, M.E. Queen's Univ., *Irel.*, M. Inst. C.E. I., Assoc. M. Can. Soc. C.E., Assoc. M. Am. Soc. C.E., L.S., 'The Grove,' off Queen-street, Woollahra.
1891	P 1	Hedley, Charles, F.L.S., Assistant in Zoology, Australian Museum, Sydney.
1900	P 3	Helms, Richard, Experimentalist, Department of Agriculture.
1906		Henning, Edmund Tregenna, B E. *Syd.*, 'Passy,' Hunter's Hill.
1899		Henderson, J., F.R.E.S., Manager, City Bank of Sydney, Pitt-st.
1899		Henderson, S., M.A., Assoc. M Inst. C.E., Equitable Building, George-street.
1884	P 1	Henson, Joshua B., Assoc. M. Inst. C.E., Hunter District Water Supply and Sewerage Board, Newcastle.
1907		Hepburn, Charles Graham, Assoc. M. Inst. C E., 169 King-street.
1905		Hill, John Whitmore, Architect, 'Willamere,' May's Hill, Parramatta.
1876	P 2	Hirst, George D., F.R.A.S., 379 George-street.
1896		Hinder, Henry Critchley, M.B., C.M. *Syd.*, 147 Macquarie-st.
1892		Hodgson, Charles George, 157 Macquarie-street.
1901		Holt, Thomas S., 'Sutherland House,' Sylvania.
1904		Holt, Rev. William John, M.A., St. Marys.
1905		Hooper, George, Registrar, Sydney Technical College; p.r. 'Branksome,' Henson-street, Summer Hill.
1905		Hoskins, George J., M. I. Mech. E., Burwood Road, Burwood.
1907		Hoskins, George Herbert, 'St. Cloud,' Burwood-rd., Burwood.
1891	P 2	Houghton, Thos. Harry, M. Inst. C.E., M. I. Mech. E., 68 Pitt-street.
1906		Howle, Walter Creswell, Medical Practitioner, Pambula, New South Wales.
1904		Jaquet, John Blockley, A.R.S.M., F.G.S., Acting Chief Inspector of Mines, Geological Surveyor, Department of Mines.
1904		Jenkins, R. J. H., Fisheries Commissioner, 'Pyalla,' 13A Selwyn-street, Moore Park.
1905	P 3	Jensen, Harold Ingemann, B. Sc., Macleay Fellow of the Linnean Society of New South Wales, Sydney University.
1907		Johnson, T. R., M. Inst. C.E., Chief Commissioner of New South Wales Railways.
1902		Jones, Henry L., Assoc. Am. Soc. C.E., 14 Martin Place.
1884		‡Jones, Llewellyn Charles Russell, Solicitor, Falmouth Chambers, 117 Pitt-street.

Elected		
1867		Jones, Sir P. Sydney, Knt., M.D. *Lond.*, F.R.C.S. *Eng.*, 16 College street, Hyde Park; p.r. 'Llandilo,' Boulevard, Strathfield.
1876	P 2	Josephson, J. Percy, Assoc. M. Inst. C.E., Stephen Court, 81 Elizabeth-street; p.r. Kallara.
1878		Joubert, Numa, 'Terranora,' Chinderah, Tweed River.
1907		Kaleski, Robert, Agricultural Expert, Holdsworthy, Liverpool.
1883		Kater, The Hon. H. E., J.P., M.L.C., Australian Club.
1873		Keele, Thomas William, M. Inst. C.E., Harbour Trust, Circular Quay.
1906		Keenan, Rev. Bernard, D.D. etc., 'Royston,' Rosé Bay.
1887		Kent, Harry C., M.A., F.R.I.B.A., Bell's Chambers, 129 Pitt-st.
1903	P 1	Kennedy, Thomas, Assoc. M. Inst. C.E. Public Works Department.
1901		Kidd, Hector, M. Inst. C.E., M. I. Mech. E., 'Craig Lea,' 15 Mansfield-street, Glebe Point.
1891		King, Christopher Watkins, Assoc. M. Inst. C.E., L.S., Public Works Department, Newcastle.
1896		King, Kelso, 120 Pitt-street.
1892		Kirkcaldie, David, Commissioner, New South Wales Government Railways, Sydney.
1878		Knaggs, Samuel T., M.D. *Aberdeen*, F.R.C.S. *Irel.*, 1 Lyons Terrace, Hyde Park.
1881	P 17	Knibbs, G. H., F.R.A.S., Memb. Internat. Assoc. Testing Materials; Memb. Brit. Sc. Guild; Commonwealth Statistician, Melbourne.
1877		Knox, Edward W., 'Rona,' Bellevue Hill, Double Bay.
1906		Lee, Alfred, Merchant, 'Glen Roona,' Penkivil-st., Bondi.
1874	P 3	Lenehan, Henry Alfred, F.R.A.S., Government Astronomer, Sydney Observatory. *Vice-President.*
1883		Lingen, J. T., M.A. *Cantab.*, 167 Phillip-street.
1901		Little, Robert, 'The Hermitage,' Rose Bay.
1872	P 57	Liversidge, Archibald, M.A. *Cantab.*, LL.D., F.R.S., Hon. F.R.S. *Edin.*, Assoc. Roy. Sch. Mines, *Lond.*; F.C.S., F.G.S., F.R.G.S.; Fel. Inst. Chem. of Gt. Brit. and Irel.; Hon. Fel. Roy. Historical Soc. *Lond.*; Mem. Phy. Soc. *Lond.*; Mineralogical Society, *Lond.*; Edin. Geol. Soc.; Mineralogical Society, *France;* Corr. Mem. Edin. Geol. Soc.; New York Acad. of Sciences; Roy. Soc. *Tas.*; Roy. Soc., *Queensland;* Senckenberg Institute, *Frankfurt;* Société d' Acclimat., *Mauritius;* Foreign Corr. Indiana Acad. of Sciences; Hon. Mem. Roy Soc., *Vict;* N. Z. Inititute; K. Leop. Carol. Acad., *Halle a/s*; The United University Club, Suffolk-st., Pall Mall, London W.
1906		Loney, Charles Augustus Luxton, M. Am. Soc. Refr. E., Equitable Building, George-st.
1884		MacCormick, Alexander, M.D., C.M. *Edin.*, M.R.C.S. *Eng.*, 185 Macquarie-street, North.
1887		MacCulloch, Stanhope H., M.B., C.M. *Edin.*, 24 College-street.

Elected		
1897		MacDonald, C. A., C.E., 63 Pitt-street.
1878		MacDonald, Ebenezer, J.P., c/o Perpetual Trustee Co. Ld., 2 Spring-street.
1868		MacDonnell, William J., 4 Falmouth Chambers, 117 Pitt-st.
1903		McDonald, Robert, J.P., Acting Under Secretary for Lands; p.r. 'Wairoa,' Holt-street, Double Bay.
1891		McDouall, Herbert Crichton, M.R.C.S. *Eng.*, L.R.C.P. *Lond.*, D.P.H. *Cantab.*, Hospital for Insane, Gladesville.
1904		MacFarlane, Edward, J.P., Under Secretary for Lands, Chief Surveyor of the State, N.S.W.; Chairman Local Government Advisory Board; F.R.A.S., Mem. Inst. Surv. N.S.W.; 'St. Julians,' Wycombe and Karraba Roads, Neutral Bay.
1906		McIntosh, Arthur Marshall, Dentist, 'Dalmore,' Albert Avenue, Chatswood.
1891	P 2	McKay, R. T., Assoc. M. Inst. C.E., 'Tranquilla,' West-st., North Sydney.
1893		McKay, William J. Stewart, B.Sc., M.B., Ch.M., Cambridge-street, Stanmore.
1876		Mackellar, The Hon. Charles Kinnaird, M.L.C., M.B., C.M. *Glas.*, Equitable Building, George-street.
1904		McKenzie, Robert, Sanitary Inspector, (Water and Sewerage Board), 'Stonehaven Cottage,' Bronte Road, Waverley.
1880	P 9	McKinney, Hugh Giffin, M.E., Roy. Univ. *Irel.*, M. Inst. C.E., Sydney Safe Deposit, Paling's Buildings, Ash-st., Sydney.
1903		McLaughlin, John, Solicitor, Clement's Chambers, 88 Pitt-st.
1876		MacLaurin, The Hon. Sir Henry Normand, M.L.C., M.A., M.D., L.R.C.S. *Edin.*, LL.D. *St. Andrews*, 155 Macquarie-street.
1901	P 1	McMaster, Colin J., Chief Commissioner of Western Lands; p.r. Wyuna Road, Woollahra Point.
1894		McMillan, Sir William, 'Logan Brae,' Waverley.
1899		MacTaggart, J. N. C., M.E. *Syd.*, Assoc. M. Inst. C.E., Water and Sewerage Board, 341 Pitt-street.
1882	P 1	Madsen, Hans F., 'Hesselmed House,' Queen-st., Newtown.
1883	P 17	Maiden, J. Henry, J.P., F.L.S., Hon. Fellow Roy. Soc., S.A.; Hon. Memb. Nat. Hist. Soc., W.A.; Netherlands Soc. for Promotion of Industry; Philadelphia Coll. Pharm.; Pharm. Soc. N.S.W.; Brit. Pharm. Conf.; Corr. Fellow Terapeutical Soc., Lond.; Corr. Memb. Pharm. Soc. Great Britain; Bot. Soc. Edin.; Soc. Nac. de Agricultura (Chile); Soc. d' Horticulture d' Alger; Union Agricole Calédonienne; Soc. Nat etc., de Chérbourg; Roy. Soc. Tas.; Inst. Nat. Genévois; Government Botanist and Director, Botanic Gardens, Sydney. *Hon. Secretary.*
1906		Maitland, Louis Duncan, Dental Surgeon, 6 Lyons' Terrace, Liverpool-street.
1880	P 1	Manfred, Edmund C., Montague-stceet, Goulburn.
1897		Marden, John, B.A., M.A., LL.B. *Melb.*, LL.D. *Syd.*, Principal, Presbyterian Ladies' College, Sydney.
1875	P 24	Mathews, Robert Hamilton, L.S., Assoc. Etran. Soc. d' Anthrop. de Paris; Cor. Mem. Anthrop. Soc., Washington, U.S.A.; Cor. Mem. Anthrop. Soc., Vienna, Cor. Mem. Roy. Geog. Soc. Aust., Queensland; 'Carcuron,' Hassall-st., Parramatta.

Elected		
1903		Meggitt, Loxley, Manager Co-operative Wholesale Society, Alexandria.
1896	P 7	Merfield, Charles J., F.R.A.S., Mitglied der Astronomischen Gesellschaft, Observatory, Sydney.
1905		Miller, James Edward, Barton-st., Cobar.
1887		Miles, George E., L.R.C.P. *Lond.*, M.R C.S. *Eng.*, The Hospital, Rydalmere, near Parramatta.
1903		Minell, W. Percy, Incorporated Accountant, Martin Chambers, Moore-street,
1889	P 8	Mingaye, John C. H , F.I.C., F.C.S., Assayer and Analyst to the Department of Mines, Government Metallurgical Works, Clyde; p.r. Campbell-street, Parramatta.
1879		Moore, Frederick H., Illawarra Coal Co., Gresham-street.
1877		‡Mullens, Josiah, F.R.G.S., 'Tenilba,' Burwood.
1879		Mullins, John Francis Lane, M.A. *Syd.*, 'Killountan,' Challis Avenue, Pott's Point.
1887		Munro, William John, B.A., M.B., C.M., M.D., *Edin.*, M.R.C.S. *Eng.* 213 Macquarie-street; p.r. 'Forest House,' 182 Pyrmont Bridge Road, Forest Lodge.
1876		Myles, Charles Henry, 'Dingadee,' Burwood.
1893	P 1	Nangle, James, Architect, 'St. Elmo,' Tupper-st., Marrickville.
1901		Newton, Roland G., B.A. *Syd.*, 'Walcott,' Boyce-st., Glebe Point.
1891		‡Noble, Edwald George, Public Works Department, Newcastle.
1893		Noyes, Edward, Assoc. Inst. C.E., Assoc. I. Mech. E., c/o Messrs. Noyes Bros., 109 Pitt-street.
1903		Old, Richard, Solicitor, 'Waverton,' Bay Rd., North Sydney.
1896		Onslow, Lt. Col. James William Macarthur, Camden Park, Menangle.
1875		O'Reilly, W. W. J,, M.D., M. Ch., Q. Univ. *Irel.* M.R.C.S. *Eng.*, 197 Liverpool-street, Hyde Park.
1891		Osborn, A. F., Assoc. M. Inst. C.E., Public Works Department, Cowra.
1883		Osborne, Ben. M., J.P., 'Hopewood,' Bowral.
1906		Oschatz, Alfred Leopold, Teacher of Languages, 46 High-st., North Sydney.
1903		Owen, Rev. Edward, B.A., All Saints' Rectory, Hunter's Hill.
1880		Palmer, Joseph, 96 Pitt-st.; p.r. Kenneth-st., Willoughby.
1878		Paterson, Hugh, 197 Liverpool-street, Hyde Park.
1906		Pawley, Charles Lewis, Dentist, 137 Regent-street.
1901		Peake, Algernon, Assoc. M. Inst. C.E., 25 Prospect Road, Ashfield.
1899		Pearse, W., Union Club; p.r. Moss Vale.
1877		Pedley, Perceval R., 227 Macquarie-street.
1899		Petersen, T. Tyndall, Member of Sydney Institute of Public Accountants, Copper Mines, Burraga.
1879	P 7	Pittman, Edward F., Assoc. R. S. M., L.S., Under Secretary and Government Geologist, Department of Mines.
1896		Plummer, John, 'Northwood,' Lane Cove River; Box 413 G.P.O.

Elected		
1881		Poate, Frederick, Lands Office, Moree.
1879		Pockley, Thomas F. G., Commercial Bank, Singleton,
1887	P 2	Pollock, James Arthur, B.E. Roy. Univ. *Irel.*, B.Sc., *Syd.*, Professor of Physics, Sydney University.
1896		Pope, Roland James, B.A. *Syd.*, M.D., C.M., F.R.C.S. *Edin.*, Ophthalmic Surgeon, 235 Macquarie-street.
1893		Purser, Cecil, B.A., M.B., Ch.M. *Syd.*, 'Valdemar,' Boulevard, Petersham.
1901	P 1	Purvis, J. G. S., Water and Sewerage Board, 341 Pitt-street.
1876		Quaife, F. H., M.A., M.D., Mast. Surg. *Glas.*, 'Hughenden,' 14 Queen-street, Woollahra. *Vice-President.*
1890	P 1	Rae, J. L. C., 'Endcliffe,' Church-street, Newcastle.
1902	P 1	Ramsay, Arthur A., Assistant Chemist, Department of Agriculture, 136 George-street.
1865	P 1	‡Ramsay, Edward P., LL.D. *St. And.*, F.R.S.E., F.L.S., 8 Palace-street, Petersham.
1890		Rennie, George E., B.A. *Syd.*, M.D. *Lond.*, M.R.C.S. *Eng.*, 159 Macquarie-street.
1906		Redman, Frederick G., 'Honda,' Shell Cove Road, Neutral Bay.
1870		‡Renwick, The Hon. Sir Arthur, Knt., M.L.C., B.A. *Syd.*, M.D., F.R.C.S. *Edin.*, 325 Elizabeth-street.
1902		Richard, G. A., Mount Morgan Gold Mining Co., Mount Morgan, Queensland.
1906		Richardson, H. G. V., Draftsman, Newcastle-street, Rose Bay.
1903	P 2	Rooke, Thomas, Assoc. M. Inst. C.E., Union Club, Sydney.
1893	P 1	Roberts, W. S. de Lisle, C.E., 'Kenilworth,' Penshurst.
1892		Rossbach, William, Assoc. M. Inst. C.E., Public Works Department, Sydney.
1884		Ross, Chisholm, M.D. *Syd.*, M.B., C.M. *Edin.*, 147 Macquarie-st.
1895	P 1	Ross, Herbert E., Equitable Building, George-street.
1904	P 2	Ross, William J. Clunies, B.Sc. *Lond. & Syd.*, F.G.S., Lecturer in Chemistry, Technical College, Sydney.
1882		Rothe, W. H., Colonial Sugar Co., O'Connell-street, and Union Club.
1897		Russell, Harry Ambrose, B.A., Solicitor, c/o Messrs. Sly and Russell, 369 George-street; p.r. 'Mahuru,' Fairfax Road, Bellevue Hill.
1893		Rygate, Philip W., M.A., B.E. *Syd.*, Assoc. M. Inst. C.E., Phœnix Chambers, 158 Pitt-street.
1905		Scheidel, August, Ph. D., Managing Director, Commonwealth Portland Cement Co., Sydney; Union Club.
1899		Schmidlin, F., 83 Elizabeth-street, Sydney.
1892	P 1	Schofield, James Alexander, F.C.S., A.R.S.M., University, Sydney
1905		Scott, Ernest Kilburn, Assoc. M. Inst. C.E., M. I. Mech. E., M.I.E.E., Consulting Engineer, and Lecturer in Electrical Engineering, The University, Sydney.
1856	P 1	‡Scott, Rev. William, M.A. *Cantab.*, Kurrajong Heights.

Elected		
1877	P 4	Selfe, Norman, M. Inst. C.E., M. I. Mech. E., Victoria Chambers, 279 George-street.
1904	P 1	Sellors, R. P., B.A. *Syd.*, 'Cairnleith,' Military Road, Mosman.
1891		Shaw, Percy William, M. Inst. C.E., Australian Smelting Corporation, Dapto.
1883	P 3	Shellshear, Walter, M. Inst. C.E., Inspecting Engineer, Existing Lines Office, Bridge-street.
1905		Simpson, D. C., M. Inst. C.E., N.S. Wales Railways, Redfern; p.r. 'Omapere,' Lane Cove Road, North Sydney.
1900		Simpson, R. C., Technical College, Sydney.
1882		Sinclair, Eric, M.D., C.M. *Glas.*, Inspector-General of Insane, 9 Richmond Terrace, Domain; p.r. Cleveland-street, Wahroonga.
1893		Sinclair, Russell, M. I. Mech. E, etc., Vickery's Chambers, 82 Pitt-st.
1891	P 3	Smail, J. M., M. Inst. C.E., Chief Engineer, Metropolitan Board of Water Supply and Sewerage, 341 Pitt-street.
1906		Small, Frederick Henry, M. Inst. C.E., 'Rotherwood,' Gordon-rd., Chatswood.
1907		Smith, Guy P., General Chemical Co., Parramatta-rd., Clyde.
1893	P 34	Smith, Henry G., F.C.S., Assistant Curator, Technological Museum, Sydney.
1907		Smith, Horace Alexander, F.S.S., 'Warwick,' Lang-st., Mosman.
1874	P 1	‡Smith, John McGarvie, 89 Denison-street, Woollahra.
1886		Smith, Walter Alexander, M. Inst. C.E., Public Works Department, 12A Phillip-street.
1896		Spencer, Walter, M.D. *Brux.*, 13 Edgeware Road, Enmore.
1892	P 1	Statham, Edwyn Joseph, Assoc. M. Inst. C.E., Cumberland Heights, Parramatta.
1900		Stewart, J. D., M.R.C.V.S., Government Veterinary Surgeon, Department of Agriculture; p.r. Cowper-street, Randwick.
1903		Stoddart, Rev. A. G., The Rectory, Manly.
1883	P 4	Stuart, T. P. Anderson, M.D., LL.D. *Edin.*, Professor of Physiology, University of Sydney; p.r. 'Lincluden,' Fairfax Road, Double Bay. *Vice-President.*
1901	P 2	Süssmilch, C. A., Technical College, Sydney.
1907		Sutherland, David Alex., F.I.C., Equitable Building, George-st.
1906		Taylor, Allen, 'Ellerslie,' 85 Darlinghurst Road.
1906		Taylor, Horace, Registrar, Dental Board, 7 Richmond Terrace, Domain.
1905		Taylor, John M., M.A., LL.B. *Syd.*, 'Woonona,' 43 East Crescent-street, McMahon's Point, North Sydney.
1893		‡Taylor, James, B.Sc., A.R.S.M., 'Adderton,' Dundas.
1899		Teece, R., F.I.A., F.F.A., General Manager and Actuary, A.M.P. Society, 87 Pitt-street.
1861	P 19	Tebbutt, John, F.R.A.S., Private Obtervatory, The Peninsula, Windsor, New South Wales.
1896		Thom, John Stuart, Solicitor, Athenæum Chambers, 11 Castlereagh-street.
1878		Thomas, F. J., Newcastle and Hunter River Steamship Co., 147 Sussex-street.
1879		Thomson, Hon. Dugald, M.H.R., Carabella-st., North Sydney.
1885	P 2	Thompson, John Ashburton, M.D. *Brux.*, D.P.H. *Cantab.*, M.R.C.S. *Eng.*, Health Department, Macquarie-street.

Elected		
1896		Thompson, Capt. A. J. Onslow, Camden Park, Menangle.
1892		Thow, William, M. Inst. C.E., M. I. Mech. E., Locomotive Department, Eveleigh.
1894		Tooth, Arthur W., Kent Brewery, 26 George-street, West.
1879		Trebeck, P. C., F. R. Met. Soc, 12 O'Connell-street.
1900		Turner, Basil W., A.R.S.M., F.C.S., Wood's Chambers, Moore-st.
1905		Turner, John William, Superintendent of Technical Education Technical College, Sydney.
1883		Vause, Arthur John, M.B., C.M. *Edin.*, 'Bay View House,' Tempe.
1890		Vicars, James, M.C.E., City Engineer and Surveyor, Adelaide.
1892		Vickery, George B, 78 Pitt-street.
1903	P 3	Vonwiller, Oscar U., B.Sc., Demonstrator in Physics, University of Sydney.
1876		Voss, Houlton H., J P., Union Club, Sydney.
1906		Wade, James Scargill, Assoc. M. Inst. C.E., Public Works Department. Manilla, N.S.W.
1898	P 1	Wade, Leslie A. B., M. Inst. C.E., Department of Public Works.
1907		Waley, F. G., Assoc. M. Inst. C.E., c/o Belambi Coal Co. Ltd., Bridge-street.
1879		Walker, H. O., Commercial Union Assurance Co., Pitt-street.
1899		‡Walker, Senator The Hon. J. T., 'Rosemont,' Ocean-street, Woollahra.
1901		Walkom, A. J., A.M.I.E.E.. Electrical Branch, G.P.O., Sydney.
1891	P 1	Walsh, Henry Deane, B E., T.C. *Dub.*, M. Inst. C E., Engineer-in-Chief, Harbour Trust, Circular Quay.
1903		Walsh, Fred., George and Wynyard-streets, p r. 'Walworth,' Park Road, City E.
1901		Walton, R. H., F C.S., 'Flinders,' Martin's Avenue, Bondi.
1898		Wark, William, Assoc. M. Inst. C.E., 9 Macquarie Place; p.r. Kurrajong Heights.
1883	P 16	Warren, W. H., Wh. Sc., M. Inst. C.E., Mem. Am. Soc. C.E., Member of Council of the International Society for Testing Materials, Professor of Engineering, University of Sydney.
1876		Watkins, John Leo., B A. *Cantab*, M.A. *Syd*, Parliamentary Draftsman, Attorney General's Department, Macquarie-st.
1876		Watson, C. Russell, M.R.C.S. *Eng*, 'Woodbine,' Erskineville Road, Newtown.
1897		Webb, Frederick William, C.M.G., J.P., 'Livadia,' Manly.
1903		Webb, A. C. F., M.I.E.E., Vickery's Chambers, 82 Pitt-street.
1892		Webster, James Philip, Assoc. M. Inst. C.E., L.S., *New Zealand*, Town Hall, Sydney.
1907		Weedon, Stephen Henry, C.E., 'Kurrowah,' Alexandra-street, Hunter's Hill.
1867		Weigall, Albert Bythesea, B.A. *Oxon.*, M.A. *Syd.*, Head Master, Sydney Grammar School, College-street.
1907		Welch, William, F.R.G.S., 'Roto-iti,' Boyle-street, Mosman.
1902		Welsh, David Arthur, M.D., M.A., B.Sc., Professor of Pathology, Sydney University, Glebe.
1881		‡Wesley, W. H.
1906		Whitehead, Lindsay, Bank of N. S. Wales, George-street.

Elected		
1892		White, Harold Pogson, F.C.S., Assistant Assayer and Analyst, Department of Mines; p.r. 'Quantox,' Park Road, Auburn.
1877		‡White, Rev. W. Moore, A.M., LL.D., T.C.D.
1879		‡Whitfeld, Lewis M.A. *Syd.*,'Glencoe,' Lower Forth-st. Woollahra
1907		Wiley, William, 'Thurlow,' Neutral Bay.
1883		Wilkinson, W. Camac, M.D. *Lond.*, M.R.C.P. *Lond.*, M.R.C.S. *Eng.*, 213 Macquarie-street.
1876		Williams, Percy Edward, Commissioner, Government Savings Bank, Sydney.
1901		Willmot, Thomas, J.P., Toongabbie.
1878		Wilshire, James Thompson, F.R.H.S., J.P., 'Coolooli,' Bennet Road, Neutral Bay.
1879		Wilshire, F. R., Police Magistrate, Penrith.
1890		Wilson, James T., M.B., Ch. M., *Edin.*, Professor of Anatomy, University of Sydney.
1907		Wilson, William Claude, Oxford-street, Epping.
1891		Wood, Percy Moore, L.R.C.P. *Lond.*, M.R.C.S. *Eng.*, 'Redcliffe,' Liverpool Road, Ashfield.
1906	P 3	Woolnough, Walter George, D. Sc., F G S., Demonstrator in Geology, University of Sydney.
1902		Wright, John Robinson, Lecturer in Art, Technical College, Harris-street, Sydney.

Honorary Members.

Limited to Thirty.

M.—Recipients of the Clarke Medal.

1875		Bernays, Lewis A., C.M.G., F.L.S., Brisbane.
1905		Cannizzaro, Stanislao. Professor of Chemistry, Reale Università Rome.
1900		Crookes, Sir William, F.R.S., 7 Kensington Park Gardens, London W.
1905		Fischer, Emil, Professor of Chemistry, University, Berlin.
1880	M	Hooker, Sir Joseph Dalton, K.C.S.I., M.D., C.B., F.R.S., &c., c/o Director of the Royal Gardens, Kew.
1892		Huggins, Sir William, K.C.B., D.C.L., LL.D., F.R.S., &c., 90 Upper Tulse Hill, London, S.W.
1901		Judd, J. W., C.B., LL.D., F.R.S., F.G.S., Professor of Geology, Royal College of Science, London; 30 Cumberland Road, Kew, England.
1903		Lister, Right Hon. Joseph, Lord, O.M., B.A., M.B., F R.C S. D.C.L., F R.S., Hon. M. Inst. C.E., etc., 12 Park Crescent, Portland Place, London, W.
1901		Newcomb, Professor Simon, LL.D., Ph. D., For. Mem. R.S. Lond., United States Navy, Washington.
1905		Oliver, Daniel, LL.D., F.R.S., Emeritus Professor of Botany, University College, London.
1894		Spencer, W. Baldwin, M.A., C.M.G., F.R.S., Professor of Biology, University of Melbourne.
1900	M	Thiselton-Dyer, Sir William Turner, K.C.M.G., C.I.E., M.A., B.Sc. F.R.S., F.L.S., late Director, Royal Gardens, Kew.
1895		Wallace, Alfred Russel, D.C.L. *Oxon.*, LL.D. *Dublin*, F.R.S., Old Orchard, Broadstone, Wimborne, Dorset.

Elected

OBITUARY 1907-8.

Honorary Members.

1901 Baker, Sir Benjamin, K.C.B., D. Sc., LL.D., F.R.S., M. Inst. C.E., etc.
1875 Ellery, Robert L. J., F.R.S., F.R.A.S.
1875 Hector, Sir James, K.C.M.G., M.D., F.R.S.
1903 Kelvin, Right Hon. William Thomson, Lord, O.M., G.C.V.O., D.C.L., LL.D., F.R.S., Hon. M. Inst. C.E., etc.

Ordinary Members.

1903 Jenkinson, Edward H.
1904 Ramsay, David
1885 Rolleston, John C.
1876 Woolrych, F. B. W,

AWARDS OF THE CLARKE MEDAL.

Established in memory of

THE LATE REVD. W. B. CLARKE, M.A., F.R.S., F.G.S., &c.,

Vice-President from 1866 *to* 1878.

To be awarded from time to time for meritorious contributions to the Geology, Mineralogy, or Natural History of Australia. The prefix * indicates the decease of the recipient.

1878 *Professor Sir Richard Owen. K.C.B., F.R.S.

1879 *George Bentham, C.M.G., F.R.S.

1880 *Professor Thos. Huxley, F.R.S., The Royal School of Mines, London.

1881 *Professor F. M'Coy, F.R.S., F.G.S.

1882 *Professor James Dwight Dana, LL.D.

1883 *Baron Ferdinand von Mueller, K.C.M.G, M.D., PH.D., F.R.S., F.L.S.

1884 *Alfred R. C. Selwyn, LL.D., F.R.S., F.G.S.

1885 Sir Joseph Dalton Hooker, K.C.S.I., C.B., M.D., D.C.L., LL.D., &c., late Director of the Royal Gardens, Kew.

1886 *Professor L. G. De Koninck, M.D., University of Liège.

1887 *Sir James Hector, K.C.M.G., M.D., F.R.S.

1888 *Rev. Julian E. Tenison-Woods, F.G.S., F.L.S.

1889 *Robert Lewis John Ellery, F.R.S., F.R.A.S.

1890 *George Bennett, M.D. Univ. *Glas.*, F.R.C.S. *Eng.*, F.L.S., F.Z.S.

1891 *Captain Frederick Wollaston Hutton, F.R.S., F.G.S.

1892 Sir William Turner Thiselton Dyer, K.C.M.G., C.I.E., M.A., B.Sc., F.R.S., F.L.S., late Director, Royal Gardens, Kew.

1893 *Professor Ralph Tate, F.L.S., F.G.S.

1895 Robert Logan Jack, F.G.S., F.R.G.S., late Government Geologist, Brisbane, Queensland.

1895 Robert Etheridge, Junr., Government Palæontologist, Curator of the Australian Museum, Sydney.

1896 *Hon. Augustus Charles Gregory, C.M.G., M.L.C., F.R.G.S.
1900 Sir John Murray, Challenger Lodge, Wardie, Edinburgh.
1901 *Edward John Eyre.
1902 F. Manson Bailey, F.L.S., Colonial Botanist of Queensland, Brisbane.
1903 *Alfred William Howitt, D. Sc. *Cantab.*, F.G.S., Hon. Fellow Anthropol. Inst. of Gt. Brit. and Irel.
1907 Walter Howchin, F.G.S., University of Adelaide.

AWARDS OF THE SOCIETY'S MEDAL AND MONEY PRIZE.

The Royal Society of New South Wales offers its Medal and Money Prize for the best communication (provided it be of sufficient merit) containing the results of original research or observation upon various subjects published annually.

Money Prize of £25.

1882 John Fraser, B.A., West Maitland, for paper on 'The Aborigines of New South Wales.'
1882 Andrew Ross, M.D., Molong, for paper on the 'Influence of the Australian climate and pastures upon the growth of wool.'

The Society's Bronze Medal and £25.

1884 W. E. Abbott, Wingen, for paper on 'Water supply in the Interior of New South Wales.'
1886 S. H. Cox, F.G.S., F.C.S., Sydney for paper on 'The Tin deposits of New South Wales.
1887 Jonathan Seaver, F.G.S., Sydney, for paper on 'Origin and mode of occurrence of gold-bearing veins and of the associated Minerals.
1888 Rev. J. E. Tenison-Woods, F.G.S., F.L.S., Sydney, for paper on 'The Anatomy and Life-history of Mollusca peculiar to Australia.'
1889 Thomas Whitelegge, F.R.M.S., Sydney, for 'List of the Marine and Fresh-water Invertebrate Fauna of Port Jackson and Neighbourhood.
1889 Rev. John Mathew, M.A., Coburg, Victoria, for paper on 'The Australian Aborigines.
1891 Rev. J. Milne Curran, F.G.S., Sydney, for paper on 'The Microscopic Structure of Australian Rocks.'
1892 Alexander G. Hamilton, Public School, Mount Kembla, for paper on 'The effect which settlement in Australia has produced upon Indigenous Vegetation.'
1894 J. V. De Coque, Sydney, for paper on the 'Timbers of New South Wales.'
1894 R. H. Mathews, L.S., Parramatta, for paper on 'The Aboriginal Rock Carvings and Paintings in New South Wales.'
1895 C. J. Martin, B.Sc., M.B. *Lond.*, Sydney, for paper on 'The physiological action of the venom of the Australian black snake (*Pseudechis porphyriacus*).'
1896 Rev. J. Milne Curran, Sydney, for paper on 'The occurrence of Precious Stones in New South Wales, with a description of the Deposits in which they are found.'

PRESIDENTIAL ADDRESS.

By T. P. ANDERSON STUART, M.D., LL.D., Professor of Physiology, University of Sydney.

[*Delivered to the Royal Society of N. S. Wales, May 1, 1907.*]

IN selecting a subject upon which to address you, I have chosen *not* to follow a common precedent in attempting to give a retrospect of scientific work during the past year. It is not possible for any one to do this completely even for one branch of science, and besides there are plenty of such retrospects published which have been done by abler pens than mine, and by men who by geographical position have greater opportunities than I have of keeping abreast of the general progress of science. But it has occurred to me that there are matters of local interest and importance to ourselves, and of personal interest to me, which I might fitly bring before you, with a view to helping some of the various enterprises of our time and place, enterprises more or less nearly or remotely, as the case may be, connected with the kind of studies pursued by members of this Society. This was the course I followed when I had the honour of addressing you from this chair in 1894, and I am told that that address did good in directing attention to some matters at that time still under discussion but since settled satisfactorily.

The Rabbit Experiments.—The past year has been rendered interesting by the visit of Dr. Danysz in order to test the efficacy of a certain microbe in the way of destroying the rabbit. As is well known, the notion of employing some disease for this purpose has been in the minds of men here for over twenty years. When, in 1890, I was in Berlin as Commissioner for several of the Aus-

tralian Governments in the matter of the discoveries announced by Dr. Koch in that year, I saw Koch on the subject, in which he was much interested; and in the previous year I had also seen Pasteur. Bearing in mind how often some contagious disease sweeps away whole hutchfuls of rabbits in confinement, they both believed that a microbe might one day be "caught" which would prove fatal to the rabbits, and being a living organism, would spread from animal to animal. Granting, however, that this did happen, it by no means follows that the rabbits would in this way be exterminated in the open; and yet I am afraid that this has been the idea and hope of many people on the subject. The fact is, that disease organisms do not act in that way. Being parasites, if they were to kill off the animals on which they live, how would they themselves survive? For instance—the plague microbe infects rats, but rats unfortunately are by no means exterminated in any district. Again, take small-pox—probably, but not proved to be, of microbial origin—what could be more virulent in an unvaccinated community, and yet the peoples have survived. And so it is with every other disease of microbial origin. Accordingly, even if fully successful, one must not expect too much from the Danysz experiment. This microbe won't spread and spread until all the rabbits are killed off. It will in given regions lose its virulence, and rabbits immune to its influence will remain; and so, in any case, supply-stations would be needed all over the country, where the cultures would be kept up in virulence, and whence ever new supplies would necessarily be sent out. The experiments with the Danysz rat microbe, to be presently referred to, have a direct and very important bearing upon this aspect of the rabbit experiments. Altogether, the process is not quite simple, and yet it was well worth the experiment, for the suggestion once having been made the public would

not rest until the method had had a fair trial. The stake at issue is enormous. I know of one sheep station where, in January of this year, 25,000 rabbits were taken in the pit traps along the wire fences; and of another where 10,000 may be found as a solid barrier dead around the poisoned water, and through which barrier lanes have to be made for their successors to pass to the poison and a similar fate. Clearly, in face of such facts as these, incessant war must be made against the enemy—or we must abandon the country. My advice to the people is to relax no effort. Let the wire-netting and other means be proceeded with as if no microbe experiments were going on, for the disease methods will never supplant the ordinary methods. At best they are no more than poisons, living poisons if you will, but still poisons. They may be but another weapon against the enemy; the old weapons will still be needed.

The Danysz Rat-virus Experiments.—How uncertain the effects of microbes are is well exemplified by the results obtained with the microbe found by Dr. Danysz to be effective in destroying rats. In order to destroy rats and thus to combat plague, the Board of Health had on three occasions imported the virus and tried it without success, when the arrival of Dr. Danysz himself seemed a good opportunity to test the virus definitively. Dr. Danysz himself gave every assistance and exalted to the requisite degree of virulence the microbe which he had himself imported, so that the conditions could not have been more favourable for a favourable result. Nevertheless, here the virus was not successful. It evidently did not set up an epizoötic of any magnitude. The results seemed to indicate a rapid loss of virulence, which must be obviated if this virus is to be of practical utility for rat destruction and so we must go on still in the old way—remove their food supplies, afford them no shelter, catch and kill or

poison them. The bearing of these experiments and these results on the question of rabbit destruction by the aid of microbes is obvious. What grounds have we for expecting that the rabbit microbe if successful would be more successful than the rat microbe has been?

The Plague.—During the year we have entered our seventh outbreak of plague in Sydney, and it has been quite remarkable with what consistency cases in the human subject have followed the discovery of cases in the rat on the premises frequented by the people who afterwards developed the disease. Clinically, therefore, the connection between the plague rat and the plague patient has become so certain that we have not hesitated to act upon the hypothesis of a causal connection between the disease in the rat and the disease in man, and great credit is due to Dr. Ashburton Thompson for independently working out the epidemiology of the subject so fully. As a working hypothesis it seemed also most probable that the flea transferred the infective particle from the rat to man, as had been suggested by Simond in 1898, though afterwards doubted. But a long step forward has been taken in this subject in the results of the Plague Research Committee appointed conjointly by the India Office, the Royal Society of London, and the Lister Institute in London. The director of the Lister Institute, Dr. C. J. Martin, F.R.S., is well known in Sydney, where he was connected with the Department of Physiology in the University for some years. It was under Dr. Martin's direction that the experiments in India were conducted, and from the interim report published in September last, it is established beyond all doubt that the flea is a means, and probably *the* means, by which the microbe is transferred from the rat to man. Flies, ants, bugs, and lice have all been found with the bacillus in their stomachs, but it is the flea that is the plague

carrier *par excellence.* Further, the plague is a disease of the rat which is afterwards transferred to man. In other words the epizoötic precedes the epidemic. This disease in rats has been observed from great antiquity, but only after the discovery of the *Bacillus pestis* was it recognised to be really plague. This being established the intimate life-histories of the rat and of the different kinds of flea become of supreme importance, for probably these if better known would clear up many of the mysterious points in connection with plague. For instance, every year in Sydney the flea nuisance troubles us in the beginning of the year, but this is just the time at which the plague is with us. Is it also the time when the rat is most numerous? An interesting point in the Commissioners' Report is the use of the guinea pig as a flea-trap. The guinea pig normally does not harbour fleas, but they take readily to the guinea pig when they get the chance, and so the guinea pig put into plague rooms is soon attacked by the fleas, which can then be readily picked from the guinea pig or shaken or combed out after chloroforming the guinea pig and the fleas at the same time. The fleas thus collected in such rooms were largely rat fleas, and so also were those collected upon the bodies of plague patients. Fleas collected from plague rats had their stomachs full of *Bacilli pestis*, and placed upon healthy guinea pigs or healthy flealess rats communicated the disease. Healthy rats in plague rooms, but surrounded by fine protecting wire gauze, remained healthy. Obviously fleas could not get through the gauze. Surrounded by an area 6 inches wide of "tangle-foot," the animal did not become plague stricken in plague rooms as they did if unprotected. Obviously the flea does not jump so far as one usually gives it credit for. The fleas stuck in the "tangle-foot" and could be easily picked off. Of 247 caught 60% were human, 34% were rat fleas, and 6% cat fleas.

Of 85 human fleas dissected, only one had bacilli in its stomach, of 77 rat fleas 23 were infected, but the 4 cat fleas had no bacilli at all. It is thus clear that the rat fleas are the main carriers of the bacilli. Clearly also, it is not an air-borne infection, since with the cage containing the healthy animal only 2 inches from the floor in a plague room the animal is infected—at 2 feet above ground it is *not*, obviously since the flea cannot jump so high. In the absence of fleas healthy animals live quite safely in the same houses or enclosures as plague animals, but as soon as fleas are introduced the disease spreads in direct proportion to the number of fleas introduced. The roofs of native houses covered with country tiles are rat infected, and from these the fleas come down as a sort of rain upon the inhabitants, especially if the houses be dark, as they often are. With rat-proof roofs all this is avoided. Another important conclusion is, that the disease can exist in a chronic form in rats and yet can give rise to the acute form. Thus the disease lurks in the rat population during the time when there are no cases among human beings. If anything could incite our people to further vigilance and activity against the rat it is such a recital of the evidence against him. But it is strange how apathetic people are, they seem always to rely upon "the authorities" doing everything—this the authorities cannot do. My fear is that our people will drift into a position of tacit acceptance of the plague as something inevitable, and that so, Sydney will become a marked place—a place to be avoided. Already we have had it six years in succession, and yet, to my knowledge, it has not been dealt with as it ought to have been. Will this be allowed to go on?

An Experience in the Management of Contagious Diseases.—The past year has seen the death of Fritz Schaudinn, at the early age of 35. Schaudinn, only a couple of years

ago, discovered the long sought virus of syphilis in the microbe *Spirocheta pallida*, and the mention of that leads me to put on record here what seems to me to be an interesting and important circumstance. For some considerable time the minds of the Royal Naval Authorities have been perturbed owing to the prevalence of serious contagious disease in Sydney, and they had made formal representations on the subject, as well as private communications, to myself amongst others. At the same time the opening of a Female Lock Department at the Royal Prince Alfred Hospital, of which I have the honour to be Chairman of Directors, gave the opportunity of ascertaining how far successful such a department would be in a community in which no Contagious Diseases Acts are in force, and where no restraint is put on the inmates compelling them to remain in the institution until their cure is complete. Further, they are not worried by many questions about one thing and another. They are simply treated like any other sick people whom it is desirable to cure of their disease as quickly as possible. Residence here is entirely voluntary. The department is open—literally, there is no locking of doors, so that visitors enter in the ordinary way, and if the inmates were so disposed they could leave at any time. Nevertheless, out of 234 inmates between the 2nd Dec., 1905 and March 31st, 1907, only about eight left the institution while still in a contagious state. Thus, under 4% left before their 'cure' was complete. This, I claim, is a distinct success, for there are many conceivable good and sufficient reasons why a woman should occasionally leave in this way. Acting on the suggestion of the Board of Health the Government is now engaged in establishing an institution in Sydney on these voluntary lines, and it is hoped that it will do much to mitigate a great evil, without raising the vexed question of the C. D. Acts.

The Opsonin Treatment.—As you know, the mode of dealing with disease germs so as to avoid the disease to which they give rise has been to keep them and us apart —to keep our bodies away from infective sources, and to keep sources of infection away from our bodies. But do what we will, somehow or other disease germs reach us more or less frequently, and in greater or less numbers, so that absolute protection pure and simple is a hopeless task. An entirely new way of looking at the subject has gradually been gaining ground during the past few years, and especially in the past year or two it may be regarded as established. It is due to the genius of Metschnikoff, who showed that certain colourless cells of the blood can and do devour and destroy the invading organisms, and so prevent their growth and multiplication. In short, they absolutely combat the disease producers. These cells Metschnikoff called "phagocytes." If the invading organism is too much, too numerous or too strong, for the phagocytes, then these latter are overcome, the disease germs get the upper hand, and an attack of the disease is produced.

Sir Almroth Edward Wright, formerly for some years connected with the University of Sydney as Demonstrator of Physiology, is mainly responsible for the discovery that in the struggle between phagocytes and microbes, the microbes are rendered more palatable, or at least more readily devoured and destroyed by the phagocytes, by the presence of certain substances which he named "opsonins," and which are produced either by the tissues themselves or by the phagocytes. For each kind of microbe there are specific "opsonins," the presence of which in increased quantities in the blood is secured by injecting the microbe itself into the blood. This word "opsonin" is from the Greek word "opson," meaning a seasoning or sauce. After the

appearance of the increased quantities of opsonins as above, the phagocytes may be seen under the microscope to have devoured many more than the same phagocytes devour in blood in which the opsonins are not present to the same extent. In this way it is now easy to measure the degree of success with which the phagocytes in any particular patient's blood are prepared to cope with this or that kind of microbe by devouring them. The opsonins have not been isolated, we do not know what they are. What we know is their effects. The results already obtained are so favourable that opsonin departments have been opened in many European and American hospitals. It is now proposed to open such a department at the Royal Prince Alfred Hospital.

The Study of Tropical Diseases.—The results of the definite study of tropical diseases constitute one of the most remarkable achievements of medical science, and it is a matter of only the last few years. Naturally, with our numerous colonies and dependencies in tropical lands, the study of these diseases is of the greatest consequence to us as citizens of the Empire, for it is malaria that renders or has rendered uninhabitable so many of what would otherwise be the fairest parts of the earth. Whenever a tropical country is said to be "unhealthy," one may take it that it means malaria. In India malaria is said to kill twice as many people as all other epidemic diseases put together. In Italy it keeps five million acres uncultivated, and so on and so on. Happily, however, no other disease has been more thoroughly studied during the past decade, nor with happier results, for great tracts of the earth's surface have been rendered habitable which before were only fit for wild beasts of sorts. And thus the political and economic aspect of the study is most important.

Until recently the mere high temperature of tropical lands was held to be the cause of the enormous mortality,

and as the high temperature is inevitable, it was said that certain areas of the earth's surface were fit for the habitation and work of only certain races of men, and that these parts were not the white man's land. In 1850 Dr. Robert Knox declared that the English race transplanted to America and Australia would deteriorate and die out. Are we prepared to admit the truth of the prophecy? What in fact we need to know is *how* to live in the strange land. Our Indian Empire remains as hot as it ever was, yet before 1859 the mortality among the European tooops was 69 per 1000, now it is 12 or less. It used to be an article of faith in India that the children of white parents could not be reared in India; what expense and misery this entailed upon parents and children many an aching heart has told. Now it is asserted that such children can be reared as well as in England. Man certainly was an inhabitant first of some one region of the earth's surface, whence he must have migrated and become everywhere acclimatised, and consideration of the facts show that the races of animals and men are not limited by isothermal lines, but by geographical features, *i.e.*, there is no general arctic, temperate and tropical types of man, but European, Arctic, African, American, Australian, etc. And so when man migrates to tropical places he must of necessity adopt new habits to suit his new environment, and he must combat any natural enemies he finds in possession. By natural enemies, I do not mean such as lions and tigers. I mean rather the microscopic organisms that produce such parasitic diseases as malaria, and the study of these parasites and the diseases they produce is really more important than that of mere temperature. This was recognised by Mr. Chamberlain when Colonial Secretary, and it is to his initiative that the Schools of Tropical Medicine in Liverpool and London have been established.

Already we know of a considerable number of tropical diseases in Australia, such as malaria, tropical dysentery, filariasis, ankylostomiasis, yaws, beri beri, dengue, Gulf fever; but there are said to be other diseases not understood, not recognised, that require to be studied. In any case, the age of fast steamers may bring various kinds of undesirable immigrants, including diseases from other lands, against which we need to be protected by knowledge of the subject, so that we may employ the best preventive and hygienic measures.

From the accounts given by my friends, Dr. F. J. MacDonald, of Geraldton, and Dr. Peter Bancroft, of Brisbane, ankylostomiasis, or the earth eating disease, or leech worm disease Dr. MacDonald calls it, is very widely spread in North Queensland, far more so than is generally supposed, for it is not the direct so much as the indirect effects that are so difficult to recognise and yet are so fatal: dropsy, leucocythæmia, anæmia, debility, syncope, heart disease. A school mistress sent to such a district, asked if she noticed anything peculiar about the children, answered "Yes, they have a bad colour, and they never never play." As Dr. MacDonald says, "how could they, with scarcely enough blood in them to keep them alive?" Then when people are debilitated they are less able to withstand other diseases, which otherwise would not kill—such deaths are really due to the parasite, and yet are not set down to it in the returns. This, then, is one of the diseases that call for a closer study on the spot, for there is ample reason for saying that were proper measures taken the disease is quite preventible. And the same may be said of other diseases than this one.

The cause of malaria is an organism in the blood, an animal parasite of a very lowly kind, belonging to the group of Protozoa, *Plasmodium malariæ*, discovered by the

Frenchman, Laveran, in 1880. And a great many more such minute animal parasites are now known, so that they share with the lowly minute algoid plants, the bacteria, the unenviable reputation of being the causes of germ disease. This organism is transferred from the diseased to the healthy, generally, if not always, by the agency of the mosquito, as was suggested by Manson in 1894, and proved by Ross about 1898. And now all the efforts of sanitarians in this department are to find out what mosquitoes are the dangerous ones, by finding in what mosquitoes the *Plasmodium malariæ* will develop, and then finding where they breed, to destroy the larvæ. This usually means doing away with all collections of surplus water, draining or filling pools or other such collections of more or less stagnant water, or covering the surface with oil, which prevents the larvæ getting to the air, so that they die. Wells and cisterns and tanks are protected by mosquito-proof gauze. The house is protected by similar gauze, and the sleeper by mosquito curtains. Lastly, a malarious patient is isolated. All these measures are suggested by the discovery of the organism and its carrier.

Stimulated by the proved conveyance of the Plasmodium by the mosquito, and by the remarkable success which had attended the efforts of sanitarians to combat malaria, I began, some eightyears ago, to be interested in the subject, and moved the Trustees of the Australian Museum to specially collect the mosquitoes of Australia. They sent out many circulars with directions how to collect and forward the insects for identification, but owing to the apathy of the people, I suppose, their efforts produced no results. There appear to be about 34 known species in Australia, though doubtless many more remain to be identified. We have the *genera* of mosquitoes in Australia which have been

found to be dangerous in Italy and elsewhere viz. *Anopheles* and *Culex*, but as yet the dangerous *species* have not been found. For instance, Dr. Robert Dick, Medical Health Officer at Newcastle, tells me that *Anopheles annulipes* (Walker), extends from Newcastle 25 miles inland to the Maitland district, and that about Maitland also *Stegomyia notoscripta* (Skuse) is very common. *Anopheles*, as I have said, is the malaria carrier. A *Stegomyia* carries yellow fever.

As a local example of at once the tropical disease and its carrier, Dr. Dick tells me of a case of Filariasis in a boy born in that district, and who has resided only there and for a time in Queensland. In the blood of this boy *Filaria nocturna* is present and he has most distressing symptoms. Dr. Dick on several occasions hatched out the eggs of *Culex fatigans*, these mosquitoes fed on the boy and acted as efficient hosts, and since transformed filariæ were present in the labium of the mosquitoes twenty days after the feeding, they could doubtless have transferred them to any other boy to which they directed their attention, for the insects that do these things are all females. Dr. Thomas Bancroft of Brisbane who has done a great deal of splendid work in this field has shown that *Culex ciliaris* also can convey the filaria from the diseased to the healthy.

One of the most striking places to come under treatment quite recently is the Isthmus of Panama, where the great interoceanic canal is in course of construction. There in the canal zone yellow fever has been eliminated, malaria enormously reduced and the country made almost into a health resort, if we can believe many accounts. One visitor saw one harmless mosquito and heard the singing of two others—why not two singings of one?—in six days. Six thousand Americans living there lost one of their number by death in three months. In New York 30 from

the same number of men would have died in the same time. Altogether, and making the necessary allowances, one may readily admit that it is now possible to live and work in comfort and health in a region where the health difficulties formerly outweighed the engineering, and this is no less a triumph for sanitary reformers than the canal itself is for engineers.

Another example of what may be done has been reported early in this year by Koch, who went to Africa to investigate what is known as sleeping sickness, due to an organism in the blood, another minute animal parasite, *Trypanosoma gambiense*, apparently communicated by a kind of Tsetse fly. The name is from their characteristic awl-like shape, "trupanon" meaning in Greek a boring carpenter's tool, an auger. Koch found that the population of the region where he worked, near the Victoria Nyanza, had been reduced from 30,000 to 12,000. In one village only 55 survived out of over 200, and of these 22 persons on examination showed the trypanosome. Continuing his work he sought for a remedy, and reports that a substance called "atoxyl," which is an arsenic compound, meta-arsenic-anilid, $C_6H_5NH\,AsO_2$, containing 37·6% of arsenic, is as definitely specific for sleeping sickness as quinine is for malaria. This substance was not introduced by Koch, but only used by him. It had been introduced for the treatment of this disease by Thomas and Breinl, of the Liverpool School of Tropical Medicine, in 1905. It is yet too early to say whether or not this statement is somewhat sanguine, but Koch's is a good name, and commands attention, whether he is right or wrong—and he has been wrong, as for instance with regard to the human-bovine tuberculosis question, to be presently mentioned. As to the immediate effect of the injection of the drug we

may perhaps take Koch's own words that "no doubt can longer exist as to the specific action of the drug." The question is, will the effect be permanent?—and this, time alone can show. If the answer is affirmative think of the mass of human misery and suffering thus averted, and think of the fertile lands thus made habitable.

The Tsetse fly which has been longest known, was the reputed cause of the terrible horse and cattle sickness which decimated the herds of imported horses and cattle in South Africa, and has had decisive influence on colonisation and campaigns. We now know that the real cause is not the fly, but something carried by the fly. This is believed to be *Trypanosoma brucei*, called after its discoverer, Colonel David Bruce, who showed that the Tsetse fly really conveyed the Trypanosome from the native big game—zebras, antelopes, and possibly buffaloes—to the imported animals. The native animals had become tolerant of it—it multiplies in their blood too, but does not kill or even injure them. They of course are the descendants of animals which had resisted the attacks—all those that could not having been wiped out by natural selection. In precisely the same way the children of native negroes are tolerant of the malaria organism. More recently the identity of the really pathogenic organism in this disease has been again placed in doubt, but it is perhaps early as yet to say much more about it. In any case, however, the subject has a certain interest to ourselves, for there is a horse sickness in India called "Surra," in which a Trypanosome is found in the blood, and which is similar to if not identical with the corresponding disease in South Africa. But Surra is now quite prevalent in the Phillipines and parts of Malaya, with which we have a growing commerce. If by any chance the disease is transferred to Australia the losses to

stock will certainly be enormous. And as the tick-fever has come, why not Surra?

Trypanosomes in Australia.—Having regard to what I have just said as to South Africa, and to the fact that Trypanosomes have now been recognised also in South America, North Africa, the Phillipines and East India, and some of them are the cause of peculiar diseases in animals and man, it is most interesting that, last June, Dr. Angas Johnson, of Adelaide, found a typical Trypanosome in the blood of the River Murray turtle (*Chelodina longicollis)*. The examination of the blood of our various wild animals might yield results of the greatest interest and importance.

A School of Tropical Medicine for Australia.—Recently the Bishop of North Queensland has taken the subject up and conferred with authorities in the three Australian Universities, and as a result a movement is now on foot to establish at least the beginning of a School of Tropical Medicine in Australia, and it is in some measure to seek your sympathy and support that I am addressing you on the subject of tropical diseases generally. The French Colonial Minister wrote "in order to colonise we must render the colonies healthy." This is strictly applicable to our own colony—the north of our own continent and the islet of New Guinea. And unless these regions are colonised, occupied, is it not true that do what we may, they will be eventually occupied by Asiatic races, and then? Thus it will be necessary to find out what changes of habit, what measures generally, on the part of the immigrant may be needed to fit him to the new environment, and it will be perhaps even more immediately necessary to know what are the diseases to which he will be exposed, so that they may be prevented or cured. The Institute of Tropical Medicine would educate the profession of medicine, would

educate the people, and would be of incalculable benefit to all the North of Australia and the adjacent islands.

Food Supplies of the People.—First in regard to fruit pests, there should be no further delay in rigorously enforcing approved measures of treating the principal fruit destroyers. It is simply wicked, for instance, to allow, as we have all seen them, neglected apple orchards to harbour and act as breeding grounds for codlin moth. Such an orchard is simply a focus of infection for all the country around, and should be dealt with as strictly as were the vines for phylloxera. In regard to this pest, the present moment is peculiarly opportune, for apparently apple culture is to immediately expand enormously in this State, and if we are to have an export trade the matter must be attended to. What I say of apples may be applied to other fruits. The total result of neglect is that a wholesome food is dear and often bad, and the poor rather than the rich are the sufferers. It is not the good careful orchardist who is opposed to regulation, for already he takes the measures which ought to be made compulsory for all. It is the careless and negligent, he, however, is just the person whom it is necessary to coerce and to his protests no heed should be given, any more than to a man who had small-pox in his house and protested that he could have what he liked on his own premises and that his neighbours had no right to interfere and were very impudent persons for doing so. I am aware that there are other causes for the dearness of fruit in Sydney, but these are hardly so directly amenable to control.

Second, as regards purity of foods the Board of Health is to be congratulated on the success which has followed its efforts in this direction. In the matter of preservatives we were told that salicylic acid, boric acid, sulphurous acid, etc., etc., were necessary in this and that food, *e.g.*, milk, butter, sauces, cordials, beer, sau-

sages, etc., etc., but the Board set its face against them, and advised more careful and cleanly processes of manufacture and storage. The experience of the past year has proved that this has been completely successful, for the analytical returns show almost absence of these substances, and still the foods are supplied and consumed without inconvenience. Before, it was the trader who profited, and the consumer who suffered. As to the simple adulterations, *e.g.*, water added to milk—they are simple frauds of no interest to us. But in passing we may ask what ought to be done to the milk man who, it has been calculated, gains hundreds a year by adding water to the milk (?) he sells? Is simple fining sufficient? No.

Third, in regard to our fish supply something should be done to punish fishermen who wantonly destroy large hauls in order to keep up the price of fish, for a wholesome food becomes scarcer and scarcer, dearer and dearer. Having regard to the abundance and variety of fish around our shores and to the not very rigorous climatic conditions besetting the fishermen in Australia, the produce of the deep should be plentiful, good and cheap. It is in reality lacking in all these points. No doubt difficulties of distribution have their influence, but they are not insuperable, and all things considered, something might, I think, be done. Anyhow, the time has come for inquiry, and this I trust will be made forthwith in the interests of the people generally, for again it is the poor man who suffers most.

The past year has been notable for the work of the Royal Commission on Tuberculosis. It will be remembered that at the International Congress on Tuberculosis, held in London in 1891, and of which I had the honour of being a Vice-President of the Medical Section, Koch made the startling announcement that bovine and human tubercle bacilli were so different that the likelihood

of the human subject being infected from bovine sources were so small as to be negligable. This was so contrary to what we hitherto believed that it at once was seized upon by those who had financial interests at stake, to urge upon sanitary authorities the impropriety and injustice of destroying animals and meat affected by tuberculosis. Nor did this State escape the influence of Koch's pronouncement, though the Board of Health continued to act as it had always done—requiring the destruction of such animals and meat.

The Report of the Royal Commission now amply vindicates our opinion and practice, and that after one of the most exhaustive, careful aad conclusive investigations of a difficult subject ever undertaken. We may indeed say it is the last word on the subject. Two interim reports have been published, and a third will come out on the tuberculosis of pigs. "There can be no doubt but that in a certain number of cases the tuberculosis occurring in the human subject, especially in children, is the direct result of the introduction into the human body of the bacillus of bovine tuberculosis; and there also can be no doubt that in the majority at least of these cases, the bacillus is introduced through cow's milk. Cow's milk containing bovine tubercle bacilli is clearly a cause of tuberculosis and of fatal tuberculosis in man." "Of the total 60 cases investigated by us, 28 possessed clinical histories indicating that in them the bacillus was introduced through the alimentary canal. Of these, 13 contained the bovine bacillus." These facts indicate that a very large proportion of tuberculosis contracted by ingestion is due to bacilli of bovine source. "A very considerable amount of disease and loss of life, especially among the young, must be attributed to the consumption of cow's milk containing tubercle bacilli. The presence of tubercle in cow's milk can be detected, though with some

difficulty, if the proper means be adopted, and such milk ought never to be used as food. There is far less difficulty in recognising clinically that a cow is distinctly suffering from tuberculosis, in which case she may be yielding tuberculous milk. The milk coming from such a cow ought not to form part of human food, and, indeed, ought not to be used as food at all. Our results clearly point to the necessity of measures more stringent than those at present enforced being taken to prevent the sale or the consumption of such milk." Here then is the complete refutation of Koch's startling statement. We wonder how ever he could have made it. It is also justification of our own Board's position. Not laxer, but stricter must our supervision be.

A review of the infantile mortality of the Metropolis for the past ten years is most encouraging. The deaths under one year of age for 1897 – 1906 inclusive are in proportion to each 1,000 births:—1897, 129 1902, 112

1897, 129	1902, 112
1898, 153	1903. 116
1899, 120	1904, 98
1900, 109	1905, 89
1901, 120	1906, 84

This very marked decline of the infantile mortality is, I am convinced, due in large part to the better supervision of the milk and food supplies, the former being the principal food of just those members of the community whose death rate has so markedly declined. The change is too sudden to be due to any other cause than the one I mentioned. In a country, then, where population is so much to be desired, apart from other circumstances, the preservation of infant life is of the greatest importance. When so much is being said as to securing immigrants, surely it is worth while doing our utmost to preserve the life of the little immigrants of our own flesh and blood.

Marine Biological Station.—It may be within the recollection of some members that in the time of the late M. Miklouho Maclay there was a marine biological station in Port Jackson. After Maclay's death the station was dismantled, and the funds have been lying at interest all these years. Some time ago I joined in a deputation to the Government, asking for a supplement to these funds, in order that the station might be set going again, but since that time nothing has been done so far as I have heard. I think that the members of this Society might now look into the matter and see whether or not something practical might be accomplished. In other parts of the world such institutions have rendered the greatest service, and the waters of this harbour offer splendid opportunities for the samehere. In combination with the work of the Fisheries Commissioners, and in conjunction with the Biological Department of the University, we might receive from the station important contributions to our knowledge of the food fishes. The money value of the fishing industry is enormous. £400,000 is spent per annum by the Commonwealth on imported fish, much of which could easily be replaced by our own fish, for it is easy in many cases to make fish so plentiful by artificial culture that every fisherman can take all he wants, and this is a better state of matters than the vain endeavour to enforce a code of protective laws.

Co-ordination of Libraries.—Soon after my arrival in Sydney, now, alas! nearly a quarter of a century ago, I was impressed with the incomplete state of the collections of books in Sydney. To remedy this state of matters, various institutions at my suggestion combined to defray the cost of a catalogue of serial literature in Sydney, and this was published under my direction in February, 1889. This showed that some 900 serials were catalogued, but far and away the greater part

of these were incomplete, many indeed quite fragmentary. The special objects of the catalogue were to show the scientific writer what journals were open to him for reference, where they were to be found, and how far they were complete in any one library. To the librarian it showed what sets were to be completed by exchange or purchase, what sets might be discontinued owing to being not very often wanted and being already sufficiently represented in other libraries, and, money thus being set free, what other journals might be purchased. This catalogue has been found to be of the utmost value, and its idea has been adopted elsewhere. But it has long been unobtainable, and a second edition has been undertaken by a committee representing the various libraries.

Co-ordination of Laboratories.—Some two or three years ago I proposed to Mr. Barling, at that time of the Public Service Board, that the Board should try to bring under some scheme of co-operation the rather numerous scientific institutions supported by the State. I pointed out that they were each somewhat isolated from each other, being here and there about the city, more or less, according to the administrative department under which they are placed. And there is no doubt that much of what I urged is true. If they were nearer together, perhaps, but not necessarily, under one roof, a central library of reference would be a great help to work, and mutual information, advice and support would be more easily obtainable. We are all isolated enough by geographical conditions beyond our control; there is no necessity for accentuating the isolation by topographical conditions which are entirely within our control. My idea was that as far as possible the different laboratories, etc., should come under the hegemony of the University, and that as many of them as possible should be brought together and formed into some

sort of institute near the University, and I indicated the unoccupied land opposite Ross-street, as a convenient site on the main line of tramways. Were something of this sort carried into effect I do not say there would necessarily be any saving of money, although there might easily be, but I do say that there would be increased efficiency, for the University must always remain the great and growing seat of learning to which in almost every branch of science the workers naturally turn for help. In consequence of my proposal something has been done, although in such a form that, with plenty of other work to occupy my whole time, I could not see my way to accept repeated invitations to take part in the work, involving as it does endless expenditure of time in committee meetings and otherwise. Had the inclusion of the University been a part of the scheme it might have had more attraction for me. Now it is only to be a limited and domestic arrangement between certain Government departments and institutions, nevertheless I think that much good may result from the deliberations of the committee.

The Obituary for 1906-7.—The Hon. James Norton, LL.D., M.L.C., was one of our oldest members, and deeply interested in Natural History subjects. He was President of the Trustees of the Public Library, and held many honourable positions in the community. He passed away in July, at the age of 81.

The late Henry Chamberlaine Russell, B.A., C.M.G., F.R.S. Mr. Russell was a native of the State, born at Maitland, 1836, so that he was in his 71st year when he died. He took his B.A. at our University as far back as 1859, after a distinguished career there. He joined the Society in 1864. In 1870 he became Government Astronomer and his first task was to reorganise the Observatory, to secure great additions to the building,

and induce the Government to furnish it with modern instruments. From that time until his end, some 35 years, the name of Mr. Russell was indissolubly connected with the Sydney Observatory and its work. In 1874, when the transit of Venus occurred, he organised four observing parties in different parts of the State, or Colony as it was then styled. In 1878 he commenced the publication of the daily weather maps which have proved so useful, and in 1879 he presided over the first Meteorological Conference held in Australia. All along he paid great attention to the meteorology of the State and induced residents all over the State to keep these accurate records of rainfall etc., which have proved so useful in many ways. From 12, when he took charge, the number of recording stations had increased to 1800 when he died. In 1887 he attended the Astrographic Conference in Paris and agreed to co-operate with other astronomers of the world in photographing the stars, his share being a portion of the sky between 54° and 62° S., involving some 1400 places. It was while engaged in this work that the glare from the lights of the city was found to be excessive, and so, at Mr. Russell's instance, an area of seven acres at Red Hill was secured and a new observatory erected, where excellent results have been and are still being obtained. In 1886 he was elected a Fellow of the Royal Society of London, and in 1890 was made a Companion of the Order of St. Michael and St. George. He was the first President of the Australasian Association for the Advancement of Science, was Vice-Chancellor of the University for the year 1891, and has twice been my predecessor in this chair as President of the Royal Society of New South Wales. We knew him well, for no one was more constant in his attendance at our meetings, or more solicitous for the welfare of the Society. He was a frequent and voluminous contributor to our proceedings and could always be relied upon to do something or say something of

interest to us at our meetings. I am sincere, and sure that I am but expressing your own feelings, in saying that his loss will be severely felt by this Society, and that the absence of his striking figure and kindly genial personality will make a distinct blank at our meetings.

The late Mr. John Young was a very old member of the Society, and was at one time Mayor of Sydney. His public work lay in other directions than attending our meetings, but nevertheless he continued always a member, and there is plenty of opportunity for service to us by mere membership. It is an example which I would that more would follow. Do they not also serve who only stand and wait?

Sir Michael Foster, M.D., K.C.B., F.R.S. Born in 1836, he entered the medical profession and practised for six years, but in 1867 he was appointed Demonstrator of Practical Physiology at University College, London. In 1870 he went to Cambridge, where he became Professor of Physiology in 1883. It is to his efforts that is mainly due the establishment of the now important Medical School of Cambridge University. He was elected to the Royal Society of London in 1872, and for 21 years was Secretary of the Society. He was President of the British Association for the Advancement of Science in 1888. He is most widely known as the original author of Foster's Text Book of Physiology, which "reads like a novel," as I have heard it expressed. He was an Honorary member of our Society and of some of us here he was a valued personal friend, whom we shall greatly miss if we once again visit the old country.

Improvements and Additions to the Society's House.— It has fallen to my lot to be President at a time of building activity by the Society. This seems to be my constant fate—University, Royal Prince Alfred Hospital, Board of Health, Industrial Blind Institution—everywhere

the builder seems to follow me. But, I wish it was everywhere as successful as it has been here. Great credit is due to the architect, Mr. Mansfield, and to the Building Committee of the Council, Professor Liversidge and Messrs. Maiden, Guthrie, and Houghton, and especially to the last-named gentleman, who has devoted a great amount of valuable time to the immediate supervision —on behalf of the Council and Committee—of the work while in progress. Of the success of the new hall nothing need be said—we are met in it—look around and observe also the better provision for ventilation. The absence of noise from passing trams and the installation of the electric light are great comforts. The whole arrangements of the house have been transformed to render it at once beautiful and more commodious and convenient. Our most valuable collection of books will for the first time be properly housed, and when, further, owing to the letting of some of the additional rooms to kindred bodies we "stand on velvet," and also bring around us more of the scientific societies of the metropolis, it will readily be admitted that it is a change advantageous in every way.

ON SOME PECULIARITIES IN OUR COASTAL WINDS AND THEIR INFLUENCE UPON THE ABUNDANCE OF FISH IN INSHORE WATERS.

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(Communicated by F. B. GUTHRIE, F.I.C., F.C.S.)

[With Plates I. - VI.]

[*Read before the Royal Society of N. S. Wales, June 5, 1907.*]

IN compiling the statistical evidence relating to the quantity of fish obtained from various coastal waters, I found that the total catches, though fluctuating somewhat, are on the whole on an increase. The markets are now receiving a good deal more fish than formerly, and that so far is satisfactory; but such an increase is not in itself a proof of a greater abundance of fish on this coast, and we know that the development of new grounds and an increased number of men may have such an effect. It would seem that the *mode* of capture has remained almost unaltered for a very long time, and this facilitates a comparison between past and present as regards the result of the average man's work.

It is fortunate that the Departmental Inspectors stationed within some principal fishing waters, have kept a monthly record of the number of men employed and the bulk of their catches, and it is possible for each of these localities to determine *the average catch per man* for each month and for the year.

The following table records the average catch per man each month within all the fishing waters for which reliable

and detailed data is available, and the figures convey some very interesting information:—

Table I.—Shewing the Average Catch per man (in baskets equal 75lbs) each month.

Waters.	Jan.	Feb.	Mar.	Apr.	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec.	Avr.
Clarence River	27·5	26·1	29·8	40·4	35·9	25·4	25·3	25·6	30·6	29·6	31·8	23·8	29·1
Port Macquarie	13·4	14·5	13·5	20·2	17·4	14·5	13·7	14·0	12·4	18·6	14·6	13·4	14·9
Cape Hawke	16·6	20·7	20·9	16·7	19·0	18·6	20·2	18·3	17·3	21·9	17·1	13·5	18·4
Port Stephens	12·0	11·7	16·3	20·5	20·1	20·1	16·6	13·1	10·0	9·4	8·7	10·4	13·8
Lake Macquarie	13·2	14·2	16·7	14·6	15·6	13·5	12·8	12·8	14·5	16·3	16·4	12·6	14·5
Tuggerah Lakes	12·8	16·1	17·2	13·3	17·5	21·7	17·0	11·9	10·5	12·5	11·3	10·1	14·2
Lake Illawarra	19·3	19·1	25·3	20·6	25·0	20·6	20·6	22·9	23·9	15·4	12·2	11·1	19·4
Shoalhaven River ...	8·5	9·6	11·1	11·5	9·8	13·5	14·5	12·8	7·9	9·1	8·6	6·5	10·6
Clyde River	3·5	4·7	16·7	16·9	7·9	11·4	8·7	5·8	5·7	8·0	6·9	8·5	8·3
Pambula District ...	7·4	15·5	15·4	13·7	10·4	7·0	7·0	8·8	9·6	15·6	14·4	10·0	11·1
Average for all waters...	13·4	15·2	18·3	18·5	17·9	16·6	15·6	14·6	14·2	15·1	14·2	11·5	

Relative Richness of the Different Waters.—From the last vertical column it will be seen that the average monthly catch varies considerably in different localities; the three most southern waters are the poorest as far as bulk goes, while Lake Illawarra is second best. But in connection herewith, it must be remembered that a small quantity of "choice" fish is equal to much larger quantities of inferior quality; also that with existing modes of conveyance the fish from distant places realises relatively less in the markets than what is brought a shorter distance.

Seasonal fluctuation in the abundance of fish.—From the table it will be seen also that the catch is much greater at some periods of the year than at others, although the individual waters show differences in this respect. This exceeding the local average are shown above the line, and will best be seen from Diagram A (*Plate* I.), where all catches the others below. The richest season of the year is March to May, with April as a climax. This coincides with the sea-mullet season, and the secondary climax in October is mainly due to "prime" fish. The monthly (or seasonal) changes in the richness of the catches do not in any way demonstrate a corresponding fluctuation in the actual abundance of fish. It is merely an indication as to when the fish congregate in convenient places for the nets to be

hauled round them, as during the migrating periods, or an apparent scarcity is felt when the fish are scattered and in places more or less inaccessible for nets.

Annual fluctuation in the abundance of fish.—It is from a comparison of the yearly average catches that the important evidence is obtained as to whether our fisheries are improving or not, and the primary data relating thereto has been recorded in Table II.

Table II.—Showing the total catch each year and number of men employed.

A.—YEARLY CATCH (in Baskets equal 75 to 80 lbs.)

Waters.	1897	1898	1899	1900	1901	1902	1903	1904	1905	1906†
Clarence River ...	...	...	...	..	...	...	17089	24082	24164	23040
Port Macquarie ...	..	...	...	...	...	...	2843	3080	2105	1185
Cape Hawke	...	...	...	7673	10521	15099	13397	10592	11661	8922
Port Stephens ...	...	...	...	5029	8671	10436	19247	14843	16618	11754
Lake Macquarie ...	10930	12210	11539	9861	10761	10863	11627	13615	13711	8387
Tuggerah Lakes ...	9343	6259	4476	6615	8747	12524	11165	8296	6895	6918
Lake Illawarra ...	8305	4631	8971	5327	6354	8444	10841	7960	6630	5105
Shoalhaven River ...	...	...	...	...	...	4546	5752	5667	3495	4019
Clyde River	—	...	...	...	...	1937	1736	1025	1519	1689
Pambula	...	...	...	...	..	843	926	1249	992	915

B.—NUMBER OF MEN.*

Waters.	1897	1898	1899	1900	1901	1902	1903	1904	1905	1906†
Clarence River ...	...	...	...	...	...	...	86	68	83	96
Port Macquarie ...	...	...	...	...	...	...	15	17	12	6
Cape Hawke	...	...	...	40	39	48	68	55	67	68
Port Stephens ...	...	...	...	21	25	49	97	121	137	95
Lake Macquarie ...	59	65	65	65	58	53	78	80	85	79
Tuggerah Lakes ...	51	52	39	33	35	54	65	53	54	40
Lake Illawarra ...	32	29	34	27	24	36	33	34	41	36
Shoalhaven River ...	...	...	...	...	...	32	48	51	22	21
Clyde River	...	...	...	...	...	18	14	14	21	18
Pambula	...	...	...	...	...	5	6	8	11	10

* These figures represent in each case the average of the monthly returns.
† Ten months only.

The average catch per man per month for each year and each water has been recorded in Table III., where the relative difference in richness between the various localities

Table III.—Showing Monthly Catch per Man (baskets).

Waters.	1897	1898	1899	1900	1901	1902	1903	1904	1905	1906	Avr.
Clarence River	...	...	...	...	...	...	39·3	29·4	24·3	24·1	29·3
Port Macquarie	...	...	...	...	...	...	15·4	14·7	14·7	16·4	15·3
Cape Hawke	...	...	...	15·9	22·8	26·5	17·7	16·0	14·6	13·1	18·1
Port Stephens	...	...	...	19·7	28·6	19·4	16·5	10·2	10·1	12·4	16·7
Lake Macquarie	15·5	15·4	14·7	12·7	15·4	16·9	18·2	14·2	13 5	11·0	14·3
Tuggerah Lakes	15·2	10·1	9·5	17·0	20·9	19·3	15 4	13·1	10·7	17·3	14·9
Lake Illawarra	21·3	13·3	22·3	16·7	22·2	19·5	27·2	19·3	13·3	14·1	19·0
Shoalhaven River	...	...	...	...	.	11·9	10·0	9·8	13·1	18·7	12·6
Clyde River	...	...	...	...	...	12·3	10·4	6·9	6·1	13·5	9·8
Pambula District	...	...	...	...	...	15·3	12·3	13·5	7·2	9·4	11·5

is again apparent. But the object of this table is to show how the abundance of fish fluctuates from year to year within the same water, and litte assistance is required to follow the general trend of this evidence. It is apparent that during the last few years there has been a general decline in the catches, culminating about 1905; about 1901 or 1902 there was a general abundance of fish, and again a shortage about 1898. It should here be noted that as all the waters show an almost simultaneous increase and decrease it is useless to suggest that inter-migration from water to water has anything to do with this.

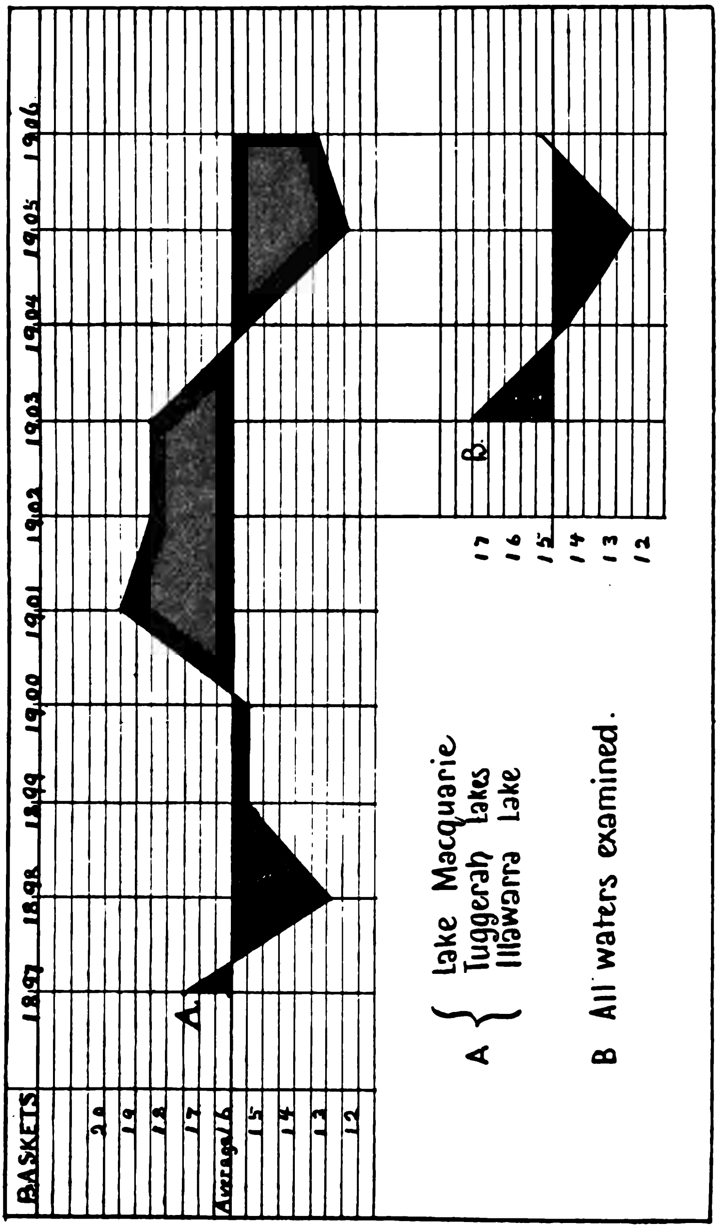
In order to obtain a still more definite idea as to the evidently periodic fluctuation in the abundance of fish on the coast, I have reduced this evidence still further by the only two methods possible, Table IV., and Table V., and the result is in both cases the same (Diagram B.). We have before us very conclusive proof of the existence of cycle-like fluctuations embracing numbers of years in each period, and this in itself, is as far as it goes a discovery of wide importance.

Tables IV. and V.—Showing Average Monthly Catch per Man.

Waters.	1897	1898	1899	1900	1901	1902	1903	1904	1905	1906
All Waters recorded	...	...	...	...	...	...	17·7	14·7	12·8	15·5
Eight Waters	...	...	...	...	...	17·6	15·3	12·8	11·1	13·3
Five Waters	..	...	...	16·4	22·0	20·3	18·0	14·6	12·5	13·3
The Three Lake Waters	17·5	12·9	15·5	15·5	19·5	18·6	18·6	15·5	12·5	13·3
Clarence River and P. Macquarie	...	...	...	...	...	...	27·4	22·1	19·5	23·5
Cape Hawke and Port Stephens	...	...	...	17 8	25·7	23·0	17·1	13·1	12·4	12·7
Lakes Macquarie, Tuggerah and Illawarra	17·5	12·9	15·5	15·5	19·5	18·6	18·6	15·5	12·5	13·3
Shoalhaven, Clyde, and Pambula Rivers	...	...	...	...	...	13·2	10·9	9·9	8·8	15·6

The next stage in my inquiry has been to seek a satisfactory explanation of these fluctuations, and primarily to determine whether they are due to natural causes, or more or less to the interference of man. A great deal of work has been expended in connection herewith, and it is only

DIAGRAM B:— Fluctuation in Abundance of Fish



after several unsuccessful attempts that what would seem a highly satisfactory result has been attained.

It is obvious that before the action of the fishermen through the capture of too great quantities, or by excessive destruction of young fish can be held directly responsible, it is necessary to find in the changes of men's numbers or methods, a fluctuation corresponding in some way with the "ups and downs" in the abundance of fish, as demonstrated in Table IV., and as such a correspondence is not apparent, it becomes necessary to look for the explanation in other directions.

As to the influence of physical conditions upon the abundance of fish, I first of all made search for periodicity in changes, and herein I received most valuable assistance from the present Commonwealth Meteorologist Mr. Hunt, who until recently was in charge of the local sub-department. I examined large quantities of records having reference to temperature, rainfall and winds, and this study was I think in itself of some value owing to the disclosure of certain meteorological phenomena that resulted, but before referring to these and their bearing upon the abundance of estuarine food-fishes in our waters, it is desirable to shortly mention such principal features in the life of these fishes as are likely to be seriously affected by prolonged climatic changes.

Two principal features in the life-history of most of our food-fishes have been fully demonstrated through some of my earlier investigations, they are in short :—

1. That the shoals of full grown fish that at certain seasons of the year are seen to enter our estuaries or leave them, are natives of this coast, they do not come from "foreign parts" nor do they leave for such places. They are our all own, and travel periodically northwards, mainly in connection with their reproduction.

2. The bulk of the spawning takes place in proximity to the open ocean where the floating eggs (and afterwards the young larvæ) are at the mercy of the coastal currents. These flow as a rule in a southerly direction past the headlands and the mouths of the estuaries, and thus it happens that the "pelagic stage" is carried back towards the locality whence the parents came. The old fish are replaced by young which remain in the estuary until ready to migrate and spawn; then the process of redistribution is repeated.

Analogous cycles of migration and drift have been found to exist in other parts of the world, notably in the North Sea, and there is reason to believe they are, with modifications, quite universal in connection with the distribution of fishes having pelagic eggs. It is well known that but an infinitely small percentage of the millions of eggs that a single fish may produce, will succeed through the various stages of development and attain maturity, and it is also very apparent that this great loss or destruction takes place mainly during the least protected stages—that is while the eggs or the young fry are drifting helplessly about in the open waters. Under these circumstances it would seem that the favourableness or otherwise of certain physical conditions, notably the currents, should in a general way afford an index to the relative successes and losses of a hatching season, and it is in this direction that my inquiries have succeeded through indirect channels, *i.e.*, the winds.

Some peculiarities in our Coastal Winds.—Through the courtesy of Mr. Hunt, I have had an opportunity of examining the Sydney anemometer records for the last twenty-four years. They contain parallel sets of figures representing respectively (1) the number of hours the winds blew from each point of the compass, and (2) the corresponding

number of miles that the atmosphere has travelled in the different directions. These automatically taken records have been totalled up each month, and to that extent I found the material conveniently prepared. It seems customary in most meteorological work to attach greatest importance to the *duration* of the "blow" (prevailing winds) and the *total mileage*, which is proportionate to the *expended energy* is frequently disregarded. That point of view might be quite good in some instances, and the prevailing wind is often gentle and harmless, but the dominating wind which travels a greater number of miles in a shorter time is also of consequence, on account of its greater violence and powers of destruction.

The method adopted in my treatment of the winds, and also its justification may be seen from the following illustrations: If in the centre of an imaginary borderless sheet of perfectly smooth ice were placed a 'feather-light' object and all friction could be disregarded, the successive winds from different points would carry this object about from place to place. The distance traversed in each direction would be equal to the mileage of each blow, and with a complete record of this mileage, it is easy at any moment to determine the whereabouts of the object. The final resting place of the latter at the end of a certain period would, in its relation to the starting point, be a means of discovering the general drift of the atmosphere during that time. The distance and direction would be expressed respectively in miles and degrees, and it would be easy to compare one period with another.

The feather-light object represents the atmosphere itself (or a particle), and the 'borderless' ice a sufficient section of the surface of the globe; the starting point or centre is in this case identical with the wind recorder, *i.e.*, Sydney Observatory.

From the twenty-four years' records of winds I first determined all necessary averages or *normals* as follows:—

(1) The average total mileage from each cardinal point for each calendar month, and for the year.

(2) The mean atmospheric drift, or the resultant wind for each of the same periods.

The tables and diagrams prepared in connection with these determinations are too voluminous to be included in this paper, and only the final results are given.

Table VI.—Showing amount of Wind in Miles, from each Point of the Compass and for each Month (Normals).

Month.	S.	S.W.	W.	N.W.	N.	N.E.	E.	S.E.	Total.
Jany. ...	1655	433	344	172	296	2358	1355	995	7608
Feby. ...	1349	347	263	121	283	2018	1112	1061	6554
March ...	1345	434	422	230	318	1618	1022	1083	6472
April ...	1157	844	1093	398	354	957	510	467	5780
May ..	950	994	1794	573	312	432	192	359	5606
June ...	624	1008	2884	982	414	223	186	287	6608
July ...	807	1139	2987	876	365	191	239	296	6850
August...	999	930	2351	816	353	506	304	362	6651
Sept. ...	873	812	1815	683	452	974	533	456	4961
Octr. ...	1274	674	1210	678	463	1501	900	704	7399
Novr. ...	1516	508	528	316	364	1999	1086	922	7239
Decr. ...	1590	354	392	272	333	2121	1423	959	7444
Total ...	14139	8477	16038	6112	4337	14898	8662	7951	79172

In Table VI. is shown the *average* amount of wind (in miles) that blows from each of the cardinal points each month, and the *average totals* for the year. As to the latter, it will be seen that the southerly is essentially a summer wind, strongest in December and January, and of least importance in the winter. This wind is third in importance of all the eight winds, and exceeds 14,000 miles a year. The south-westerly is the reverse of the southerly and fifth in importance with about 8,500 miles. The westerly is also a winter wind (in excess from May to June) and is the first in importance with about 16,000 miles a year. The north-westerly is also a winter wind and seventh in order with about 6,000 miles. The northerly is fairly generally distributed throughout the year, and is of least importance with about 4,300 miles. The north-easterly is

a typical summer wind and is reduced to a minimum in July. It is second in importance with about 14,000 miles. The easterly resembles the former, it is generally one month earlier in its fluctuations, and stands number four in importance with about 8,800 miles. The south-easterly is also a summer wind and is number six in order of importance with about 8,000 miles for the year.

We have three primary winds, *West*, *North-east* and *South*, with from 16,000 to 14,000 miles each, and the others are of secondary power. The total amount of wind that passes over one fixed point during a normal year is slightly more than 79,000 miles, and is fairly evenly distributed over the different months.

In order to discover the final result from the action of the monthly winds in analogy with the movements of the feather-light object already referred to, I have compared the opposing forces (north and south, east and west) and substracted the smaller from the larger. The four remaining balances represent the total "drift" energy for the month, and have been recorded in Table VII.

Table VII.—Showing the four dominating Winds (in miles) for each month (Normals).

Month.	S.	S.W.	W.	N.W.	N.	N.E.	E.	S.E.
January	1359	...	...	...	...	1925	1011	823
February	1066	...	...	...	...	1671	849	941
March	1027	...	...	...	...	1184	600	854
April	803	...	583	...	...	118	...	69
May	638	562	1602	215	...	...	...	...
June	210	785	2698	695	...	...	...	...
July	442	948	2698	580	...	...	...	...
August	616	424	2047	453	...	...	...	...
September ..	421	..	1282	228	...	162	...	...
October	811	...	810	...	...	827	...	31
November ...	1152	...	...	...	...	1491	558	606
December ..	1257	...	...	...	...	1767	1031	687
Dominating winds for normal year	9802	...	7171	...	...	6421	...	1840

It is of interest to note how the balance of power changes from month to month, while the peculiar characteristics of each month are also portrayed. In order to determine the final resultant power for each month, it is necessary to

resort to complicated mathematical calculations or geometrical construction in accordance with the principle of the parallelogram of forces; the latter method, which for convenience I have adopted, is with the exertion of care of sufficient accuracy for the present purpose, and it needs no detailed explanation. The yearly normal has been obtained in a similar manner, and the results are illustrated in Diagram C. (*Plate* II.)

It will be noted that from November to March, the winds blow persistently from the sea and during May to September in an almost opposite direction; April and October are peculiar to themselves, and of a neutral character. (In this and the following wind diagrams the arrows point with the wind). The yearly resultant or normal drift is interesting as regards direction and extent, it is in accord with the meteorologist's contention as regards the general ingress of the lower atmospheric layers from the pole to the equator, but it is contrary to a popular idea which is based upon the importance of prevailing winds (with us from the north-east).

The yearly resultant coincides to within a couple of degrees with the local magnetic deviation, and its relationship to the coastline might be noted. The seasonal changes already referred to are most apparent from Diagram D., (*Plate* III); this is founded upon the monthly normal winds from each point as recorded in Table VI., the arrow on the cardinals being proportionate to the mileage. The intervening areas have been coloured simply to assist the eye and are not otherwise representative. The central figure represents the normal year's winds, and has been divided into two sections—red and green—by a line along the direction of the average atmospheric drift already described, the marginal figures which represent the different months as named, have also been divided by lines parallel to the yearly drift.

From this it will be seen that the "reds" contain all winds blowing across the drift direction from west and north, while the "greens" contain those crossing from east and south. The individual months might now be considered—April and October show each about an equal quantity of red and green and have three primary winds—west, north-east, and south; in all these points the two months resemble the year, and have been placed on the dividing line—the central zone. From November to March the winds blow from north-east, east, and south, with a maximum of energy about January (midsummer); from May to September the blow is mainly from the west, with a maximum intensity about July (midwinter). It will be seen that the summer and winter are of *equal duration* (five months each) and they carry about the same mileage of wind.

Table VIII.—Showing the resultant wind-directions for each month and extent in miles (Normals).

Month.	Direction. East	Miles.	Seasons.
October ...	N. 307·50	390	AUTUMN
November	„ 284·00	2100	SUMMER
December	„ 281·00	2900	
January...	„ 281·00	3050	
February	„ 281·75	2780	
March ...	„ 291·25	2185	
April ...	„ 30·50	875	SPRING
May ...	„ 67·75	2325	WINTER
June ...	„ 86·25	3760	
July ...	„ 79·50	3825	
August ...	„ 77·75	2735	
September	„ 84·50	1325	
Resultant	„ 11·75	6700	YEAR

Having ascertained the *normal* features of the atmospheric movement for each month and for the year, it became necessary to find out to what extent individual years have differed from the mean. The object hereof was to discover whether *periodic* fluctuations do exist, and if so, to compare these with the gradual yearly increase and decrease in the abundance of fish—the assumed connection between

the two being as stated through the medium of the coastal currents. It was intended to single out such periods as would reasonably cover certain important spawning seasons, and the months involved were traced back through the twenty-four years under review. This comparison led to very interesting data meteorologically, and might with advantage be followed up by those concerned, but it would occasionally happen that within the same year one species of fish had a beneficial season while others met with reverses, and I found it desirable for the present to take all the seasons, *i.e.*, the year as a whole, and compare it with the total catch of mixed fish. From the monthly wind-mileage from the different compass points I have determined the atmospheric drift—the resultants—for each year since 1884, and find them to differ considerably from one another as regards direction and force. These yearly resultants have been set out in Diagram E, (*Plate* IV), and form an interesting study. In comparison with their average—the yearly normal—they show individually considerable differences, yet with one or two exceptions they all point north with an easterly or westerly tendency as the case may be.

It is well known that persistent winds have an all important influence upon the surface currents of the ocean; they become deviated from the normal flow, pushed aside one way or the other, accelerated in speed if the extra blow is with the currents, or temporarily brought to a standstill under certain other conditions. It is necessary therefore, when tracing the influence of the dominating or concentrated wind actions on the waters, to give regard to its two primary factors, *i.e.*, deviation from the normal and force or mileage.

A combination of these factors has been attained by disregarding them both individually and taking as their measure the nearest distance from the points of the arrows

to the yearly normal or its continuation. It will be seen that the yearly wind resultants which coincide with the direction of the normal, have no disturbing influence; everything remains normal, and the extent of the disturbance occasioned by others is proportionate to their deviations one way or the other from the average mean. The result of this comparison is recorded in Table IX., and illustrated in Diagram F *(Plate* V). The mean line of the diagram is the normal or average for all the years, and the deviations west and east are shown respectively above and below.

Table IX.—Showing the result of each year's wind-deviation (in miles) when compared with the normals.

Year.	Deviation in Miles.		Year.	Deviation in Miles.	
	West.	East.		West.	East.
1884	1425	...	1896	600	...
1885	1050	...	1897	3225	...
1886	...	4275	1898	2050	...
1887	...	3000	1899	5500	...
1888	825	...	1900	...	2200
1889	2850	...	1901	...	3075
1890	...	6000	1902	5525	...
1891	...	75	1903	3275	...
1892	1475	...	1904	2775	...
1893	...	850	1905	...	6800
1894	...	1625	1906	4875	...
1895	...	5175		...	...

From a meteorological point of view it would seem of interest that the first half of the curve, up to 1895, is nearly all *below* the average, while the remainder is nearly all above. This means that during the former period, the winds had a greater tendency off the shore than latterly.

The second period coincides with the great Australian droughts (1895 – 1903 and 1904), and it is evident that for the same reasons as the winds blow on to the coast in the summer and away from it during the winter, so does also in dry (hot) years, the whole atmospheric drift have an exaggerated westerly (inland) tendency. This as will be seen afterwards, has a direct bearing upon the fisheries.

The separation of the period into two halves of very different character, suggests also the existence of an extended cycle or wave of which the twenty-four years under review form but a portion. The deviation in the yearly winds are seen to fluctuate within periods of a few years; distinct depressions in the curve (easterly deviation) occurred in 1895-6, in 1900-1, and in 1905. The intervening maxima (westerly deviation) occurred in 1897-99, in 1902, and in 1906. Here we have a direct measure of the disturbing influence of each year's winds upon the normal ocean currents touching the east coast of Australia, more particularly of New South Wales, and its application is very interesting. (Diagram G).

From certain ocean charts it will be seen that in the central Pacific, about 8 to 10 degrees south, there is a surface current flowing parallel to the Equator in a westerly direction. On approaching the archipelago fronting the south-east coast of Asia a main, arm of the current is directed south-westerly; it passes the Fiji and Norfolk Islands and is deflected still more southerly on meeting the Australian continent about the latitude of Moreton Bay; from here it follows the coast of New South Wales and Tasmania, where on meeting an easterly current from the Australian Bight, it turns east and north-east to the coasts of New Zealand.

From continued temperature observations I have had taken on board fast going steamers running between Sydney and New Zealand ports, it appears that the centre of the warm current is normally situated somewhere within 100 to 150 miles off the New South Wales coastline in the latitude of Sydney; its western border brushes along the headlands and is known to coasting crafts and line fishermen. Having its origin in conditions prevailing elsewhere, this current would during calm weather assert itself in its

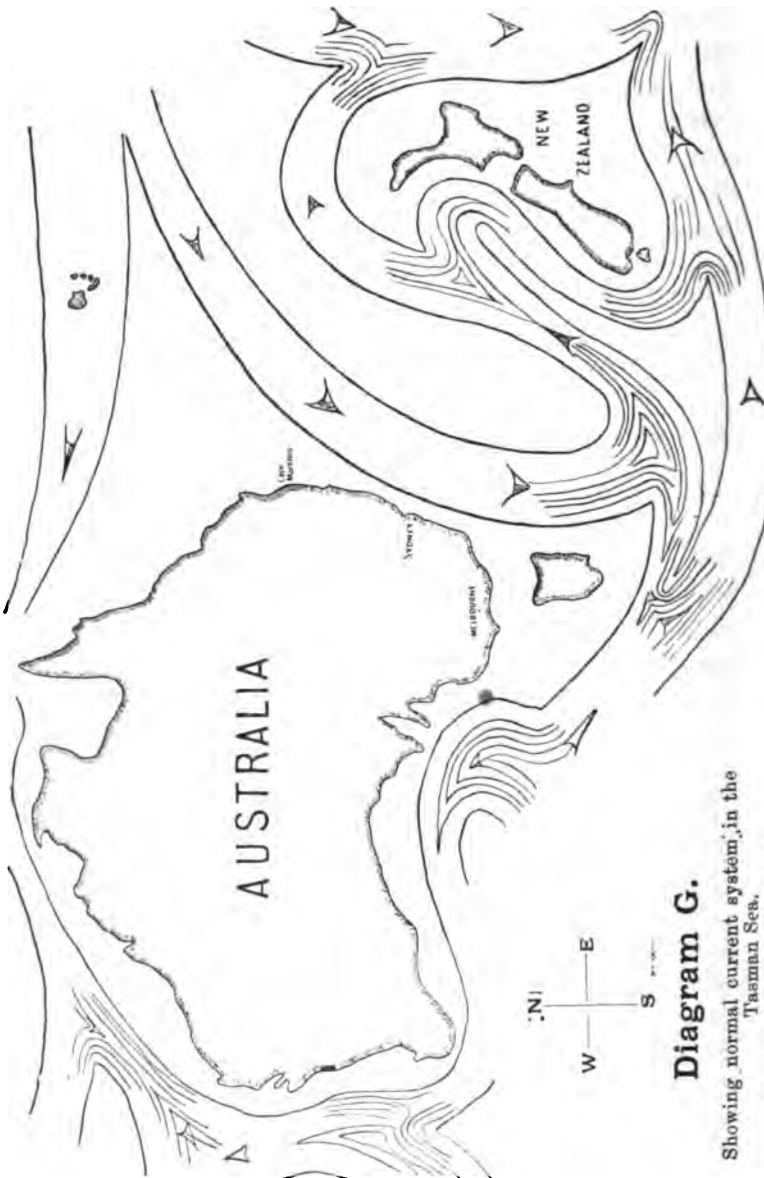


Diagram G.

Showing normal current system in the Tasman Sea.

(After an American Chart.)

normal aspect; it would continue southwards along the New South Wales coast and have maximum speed at a certain distance from the shore. But the coastal winds interfere in this arrangement and temporarily push the current on to the coast or away from it. In the latter case, during stormy blows from west etc., the main current is not only itself carried seaward, but temporarily the surface waters from the coast follow in the same direction. The direct influence of the winds upon the fate of floating fish eggs is very apparent.

(1) When normal conditions prevail, the eggs follow the coast line and drift towards inlets situated to the south from the place of spawning.

(2) When pressed harder on to the coast through excessive easterly winds, the eggs will at any rate remain very close inshore and benefit these waters.

(3) When the winds blow excessively away from the coast, the eggs follow the waters, and whatever else may happen to them, they are lost to the coast that should have benefited by their numbers.

These reasonable contentions are amply demonstrated by comparison of the fish and wind curves already referred to, and reference may be made to Diagram H (*Plate* VI). The original curves are here represented in dotted lines A, C, E, and in order to form a better idea as to their main characteristics a "smoothed" curve (based upon three-yearly averages) has been introduced (B and D). Also it should be observed that the fish curve has been set back four years, so that the actual catch at any particular period may be directly compared with the wind conditions prevailing at the time the bulk of the catch was hatched out. It will be seen that the adverse winds (under the line or easterly deviation) that prevailed in 1894 and 1895 were followed by poor catches in 1898 and 1899; during 1897,

1898 and 1899 the winds were very favourable, and four years after the best fishing was enjoyed. The winds again became very "unfriendly" in 1900 and 1901, which was followed by great scarcity of fish in 1904 and 1905. In 1902 the winds suddenly changed for the better, and it will be seen how the abundance of fish increased from the greatest scarcity in 1905 to above the average in 1906. (See curve E which represents about 90% of the total catch). In the very close and detailed correspondence that is seen to exist between the dominating wind for any particular year and the abundance of fish four years hence, it is necessary to recognise a striking demonstration of *cause* and *effect*. The possibility of coincidence is not only fully excluded, but it is seen also that while the curves correspond with one another in the present comparison, they do not fit in if compared in any other way. It is unfortunate that the fish returns are unreliable prior to 1897, but from the records available, it is certain that fish were more plentiful in 1896 than in 1897, and this evidence, though general, is of strong corroborative value as supplementing the more direct evidence for the following ten years.

In this paper it has first of all been demonstrated that the abundance of fish on this coast is fluctuating in a manner that cannot fully be ascribed to the action of man; over-fishing alone is not a sufficient explanation. Secondly it has been demonstrated that the yearly dominating wind-direction is also fluctuating, some years it tends from the sea to this coast, and at other times from the coast seawards; and thirdly we find that the "ups" and "downs" in the abundance of fish correspond with the "ins" and "outs" of the dominating wind directions four years previously. Apart from the scientific aspect of this discovery, it has also great practical consequences and a direct bearing upon legislation as to closures, etc. Further-

more it will be seen that if this evil effect of the adverse winds could be overcome by retaining the fish-eggs instead of letting them drift away, much good would be attained. Fish culture is the only means to this end, and has in many countries demonstrated its beneficial influences.

A final phase of the relation between winds and the fish is that as this year's wind conditions determine what like the fisheries shall be four years hence, viz., in 1911, and last year's winds dealt with the eggs that should make up the catches in 1910, we have in the wind records suitable materials to form a "forecast" for each of the next four years to come.

On reference to Diagram H it will be seen that as the winds in 1902, 1903, and 1904 were favourable, so ought also the fishing to be in 1906 (which happened) and in 1907 and 1908. It is not desired, however, that much prominence shall for the present be given to this apparently very important aspect of the matter. There are too great interests involved, and while the experience of time adds value to the existing evidence, those most directly concerned had better continue as formerly, by taking things by chance. In the meanwhile it will be interesting to watch future developments, and I feel confident that by each succeeding year we approach a stage of greater certainty, when fisheries investigations on a scientific basis will also in Australia become the recognised means for determining important problems, and the general guide to advancement and progress.

NOTE ON ACTION OF NITRIC ACID IN NEUTRALIZING ALKALINE SOIL.

By R. S. SYMMONDS.

(Communicated by F. B. GUTHRIE, F.I.C., F.C.S.)

[With Plate VII.]

[*Read before the Royal Society of N. S. Wales, July 3, 1907.*]

KNOWING that considerable doubt exists as to the utility of alkaline artesian water for agricultural purposes, and the injurious effects of carbonate of soda on the soil, it occurred to me that the carbonate of soda could be neutralized by nitric acid, and thereby converted into nitrate of soda—an excellent fertilizer.

With this object in view I obtained some alkaline soil that had been under irrigation by artesian bore water, and on September 28th, 1906, filled three 6 inch flower pots with the soil, No. 1 being the ordinary soil, and Nos. 2 and 3, treated with nitric acid. Two grains of wheat were sown in each pot and allowed to mature, the wheat was cut on January 28th, 1907, and the grain weighed, giving the following results:—

No. 1. Untreated ...	2·65	grams of wheat.
„ 2. Treated ...	11·30	„ „
„ 3. Treated ...	14·40	„ „

showing more than five times the yield, which was considered a very satisfactory result.

In order to make quite sure, I repeated the experiment in duplicate on February 2nd, 1907; the photographs illustrate the latter series of experiments, (*Plate* VII) and although the season (winter) was against the growth and ripening of the grain, the results show an increase of from eight to ten fold.

The pot on the left of each photograph, Nos. 1 and 5, contain the alkaline soil untreated; the other three pots contain the same soil in which the injurious effects of the alkali have been corrected by the addition of nitric acid. Nos. 2 and 6 received ·2 per cent. Nos. 3 and 7 received ·5 per cent., and Nos. 4 and 8 received 1 per cent. nitric acid.

Two grains only of wheat were grown in each pot, consequently it is fair to assume that the "stooling" properties of wheat are greatly assisted by the process, and as the pots containing ·2% HNO_3 show an increase in the yield, practically equal to those containing 1%, it is only reasonable to suppose that the same result would be obtained by the use of a much lower percentage of acid.

From these experiments, which must be regarded as purely of a preliminary nature, it is quite impossible to attempt to estimate the cost, and until the experiment has been tried in the field on a comparatively large area, I would prefer not to express an opinion on this point. Mr. Guthrie, Chemist, Department of Agriculture, on seeing the photographs of this experiment, sent to Moree for some alkaline soil, and kindly made arrangements for me to carry out larger pot experiments at the Botanic Gardens; the results of these experiments will form the subject of a paper now in preparation.

The mechanical power derivable from the pressure given in the outflow from artesian bores could probably be turned to account in producing, on the spot, electro-chemical nitric acid from the atmosphere, a process which is now being successfully carried out in Europe, at a cost of £8 3s. 6d. per ton. As the cost of raw material and power is nil, it is simply a question of plant, working expenses, and intelligent supervision. I am certainly of the opinion that this will be of the utmost importance in the future irrigation scheme of New South Wales.

Since writing the above, a paper[1] dealing with the electro-thermic combustion of atmospheric nitrogen, has come under my notice. The author of that paper refers to a process, recently investigated in Germany, as offering some novel features which render the process particularly applicable to our unique conditions, the high pressure artesian bores providing the power to produce from the atmosphere an antidote for their own toxicity, and thereby enormously increasing the fertility of the soil and rendering us independent of a precarious rainfall.

The workers of the process referred to, state that they obtained a maximum output of 440 kilos HNO_3 per kilowatt year, when using a current of 0·05 ampère of 6,000 to 10,000 periods per second, at 50,000 volts, each arc absorbing 2·5 kilowatts. So that 2·5 kilowatts (about 3·4 hp.) produced 1·1 ton of nitric acid per year.

A plant such as that mentioned could be duplicated according to the power available. There would not be any expensive transport or packing of the acid, and it would be quite unnecessary to concentrate it for our purpose—this would mean a considerable reduction in the cost of the plant and working expenses. The advantage of such a process is apparent, when working on an area of about 80,000 square miles, which is the extent of the Artesian basin of New South Wales.

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[1] Journal of the Society of Chemical Industry, 15/4/07.

NOTE ON COPPER IN ANDESITE NEAR LAUTOKA, FIJI.

By H. I. JENSEN, B.Sc., Macleay Fellow of the Linnean Society of N.S.W. in Geology.

(By permission of the Council of the Linnean Society.)

[*Read before the Royal Society of N. S. Wales, August 7, 1907.*]

Introduction.—A number of rock specimens gathered in the vicinity of Lautoka, Viti Levu, have been forwarded to me by the collector, Mr. Dan Petersen, for identification and examination. In the collection there was a specimen of copper ore with portions of the andesitic matrix imbedded in it and adhering to it. The specimen weighed about 8 ounces.

I communicated with Mr. Petersen enquiring whether any slates, granites, diorites or other metamorphic or old plutonic rocks were found in the vicinity, and received a reply stating that as far as he was able to ascertain, only such rocks as he had sent me, namely andesites, occurred in the vicinity. The specimen has the appearance of a segregation or metasomatic replacement product in the andesite. It is of a dark colour, varying from brown to bluish-black, and iridescent.

Other Similar Occurrences.—The occurrence of copper ore in andesite is not uncommon. Small quantities of copper occur in the tuffy beds of the chocolate shales at Narrabeen, N.S.W. In the andesitic tuffs of the Blackall Ranges, near Nambour and Yandina, Queensland, a greenish stain due to copper is of common occurrence. The andesites of the Bumbo quarry in the Kiama-Jamberoo district con-

tain native copper[1] and "Cupriferous Tuffs of the Passage Beds between the Triassic Hawkesbury Series and the Permo-Carboniferous Coal Measures of New South Wales."[2]

Vogt in his contribution to the Posepny-Van Hise discussion on ore deposits, maintains that copper deposits are occasionally due to magmatic differentiation. G. A. Waller considers most copper veins and deposits to be due to magmatic extraction, therefore to be primarily derived from igneous rock, from which it has been in the first place removed by heated magmatic waters.[3]

My specimen being of considerable size, and mining operations having been commenced in the vicinity of Lautoka at the time when I was testing the mineral the occurrence seemed to me to be of sufficient interest to publish the results which I arrived at.

A microscopical examination of a thin slice of the ore showed it to consist essentially of two metallic opaque minerals, one of which is of a fine blue-black colour by reflected light, the other of a soft brown tone. The blue-black mineral consists of chalcocite (Cu_2S), with perhaps more or less magnetite (Fe_3O_4). The brown mineral is bornite (copper iron pyrites Cu_3FeS_3). Both minerals are crystalline and are graphically intergrown. They form a crystalline meshwork with a dendritic or mossy appearance, in the interspaces of which are found microlites of felspar, corroded hornblende crystals, and a little biotite. In some places small aggregates of hornblende and felspar are included in the metallic mineral.

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[1] Records Geol. Surv. of N.S.W., Vol. VIII.

[2] Rept. Aust. Assoc. Adv. Science, 1888. [3] *Loc. cit.*, 1902.

[4] "There has been a find of copper ore at Navilawa, about 12 miles from Lautoka. Mining operations have commenced, and five tons of ore have been shipped. The ore is said to be turning out well, and this may perhaps be the starting of a large industry."—*Daily Telegraph*, Sydney, March 30th, 1907.

A representative portion of the specimen was selected for chemical analysis which was made in the University Chemical Laboratory, and resulted as follows:—Copper $53\frac{1}{2}\%$ iron $7\frac{3}{4}\%$, sulphur $21\frac{1}{2}\%$, insoluble $16\frac{1}{4}\%$, unestimated $1\frac{1}{2}\%$. The 'unestimated' would include substances like Al_2O_3, CaO, Na_2O, K_2O, Sb and Sn.

If the insoluble portion be left out of consideration, the copper forms about 64% of the soluble portion which indicates a mixture of chalcocite (Cu_2S) and bornite (Cu_3FeS_3). After arriving at this result, I examined half a dozen sections of andesitic rock from the same district (petrological note appended). In two of these I recognised the same blue-black and velvety-brown minerals which form the bulk of the specimen already described, with this difference that they occur in minute cubes scattered about sparingly like magnetite and pyrites in ordinary rocks. I accordingly powdered about 5 grams of each of these two rocks and mixed the powders. Then I took 5 grams of the mixture and digested it with aqua regia, precipitated the copper as sulphide and weighed it as oxide. The weight recovered was ·0017 gr. of CuO equivalent to ·034% of CuO. It is therefore evident that the andesites of the Lautoka district are copper-bearing and that the copper exists in them as sulphide. Both specimens of cupriferous andesite come from Vilau (or Ni-Vilau) near Lautoka.

Judging by the microscopic appearance, not unlike that of some alloys, the ore specimen might have originated either as a segregation (which appears most probable) formed during the cooling of the lava, or by the metasomatic replacement of a glassy base by copper sulphide, during or immediately after consolidation, through the agency of magmatic waters. The arguments in favour of the supposition that the ore is a segregation are:—

(1) The occurrence of the same sulphide minerals as rock constituents in the normal andesites of the district.

(2) The fact that most of the included crystals consist of felspar and felspar aggregates, (though green hornblende and biotite are present as well). In the case of the metasomatic replacement of a glassy base we should expect most of the inclusions to consist of ferro-magnesian minerals, these normally consolidating first in the Lautoka andesites.

(3) The thoroughly crystalline nature of the whole mass and the mossy way in which the sulphide mineral fits into the enveloping andesitic material which itself has undergone no alteration as we should expect through vapour action. The specimen has an appearance suggesting simultaneous crystallisation.

In favour of the metasomatic replacement hypothesis it might be argued:—

(*a*) That the metasomatic replacement of the base of a hypo-hyaline rock with copper sulphide could give rise to a crystalline mass of copper ore including microlites.

(*b*) That in the normal rock the cupriferous mineral consolidated early, whereas in the ore it consolidated simultaneously with or after the felspar microlites.

(*c*) That biotite occurs sparingly included in the ore, but does not occur in the normal Fijian andesites. Biotite in these rocks is however not necessarily a product of metasomatic change, as it is a mineral of common occurrence in andesites, especially in hornblendic varieties.

Against the second argument (*b*) it might be urged that in the normal rock, the copper ore being present only in minute quantities, the order of consolidation would depend mainly on the laws of solubility, whereas in the larger specimen, which represents according to the first hypothesis, a portion of the magma supersaturated with metallic sul-

phides, the order of crystallisation would depend on the laws of fusibility. In this case the felspar would separate out first being the most infusible. For these reasons it seems highly probable that the copper ore of Lautoka owes its origin to magmatic differentiation, but if not its origin is due to magmatic extraction in the lava. As far as can be judged from my specimens and information which I have received, the bornite *is not* an inclusion snatched from deep seated plutonic sources.

Petrological Note.—In view of the comprehensiveness of Dr. W. G. Woolnough's petrological descriptions of Fijian rocks, it will be unnecessary for me to give any detailed descriptions of slices of specimens sent to me, which in most respects agree in petrological characters with the porphyritic andesites described by Dr. Woolnough. The minerals most abundantly represented in the Lautoka andesites are:

(1) Felspar—this mineral occurs in most of the rocks in two generations. The phenocrysts consist of labradorite having a maximum extinction angle of $26^\circ - 27^\circ$ in symmetrical sections. They are usually twinned on the Carlsbad plan and frequently possess albite twinning as well. Pericline twinning is also but more rarely represented. Zoning is strongly in evidence, and is of two kinds. (*a*) due to inclusions, and (*b*) due to interlamellation of two kinds of felspar. Usually both kinds of zoning are present in the same crystal. In several cases the centre, an intermediate zone, and the exterior have been observed to extinguish together at a lower angle than the two zones intervening. The edges of the phenocrysts are generally corroded. The second generation of felspar consists of lathshaped microlites of a more acid felspar, such as andesine or oligoclase-andesine.

(2) A light green feebly pleochroic augite having the same colour as the hornblende and rhombic pyroxene.

These three minerals occur in the form of corroded phenocrysts and are in some rocks coexistent in equal abundance whilst in other rocks one of them may be practically absent.

(3) The hornblende is a light yellowish-green variety with extinction angles of usually between 0° and 15°, but sometimes as high as 29°. It is only feebly pleochroic and is distinguishable from the augite only by its cleavage and lower extinction angle. It is probably uralitic, secondary after augite.

(4) A greenish coloured bronzite of feeble pleochroism is invariably present and is distinguished from the hornblende by its weak double refraction, its form and its cleavage. In colour and pleochroism there is no perceptible difference between these minerals. There are small crystals of a second generation of both the hornblende and bronzite. The hornblende phenocrysts commenced to crystallise earlier and attain a greater size than those of the rhombic pyroxene.

(5) Fayalite of red colour, having the outline of olivine, occurs in two of my specimens. Dr. Woolnough informs me that the deep colour of this mineral is due to secondary heating. The colour is so deep that double refraction is completely obscured.

(6) Magnetite in steel-blue opaque grains.

(7) Ilmenite and brownish titaniferous magnetite are also present in some sections. Leucoxene occurs occasionally as a decomposed product.

(8) Copper iron pyrites and chalcocite are present in small idiomorphic grains and aggregates of grains.

(9) Decomposition products especially from the decay of felspars occur.

(10) Opal and tridymite occur especially in vesicular varieties.

The normal order of consolidation is

1. Magnetite
2. Fayalite
3. Copper Ores
4. Augite, bronzite and hornblende, 1st gen.
5. Labradorite
6. Bronzite and hornblende, 2nd gen.
7. Andesine felspar laths
8. Glass

ANALYSIS OF A SPECIMEN OF SEA-WATER FROM COOGEE.

By C. J. WHITE, Caird Scholar, University of Sydney.
(Communicated by Prof. LIVERSIDGE. LL.D., F.R.S.)

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FORCHHAMMER first definitely proved, what indeed was almost *a priori* evident, that, although the salinity of the ocean varies with locality, season, depth, etc., yet the ratio of dissolved salts to one another remains practically constant. Of course slight variations are only to be expected in coast waters, especially if landlocked or if receiving extensive river drainage, but in deep sea-waters the circulation of ocean currents etc., could fairly certainly be reckoned on to thoroughly mix the dissolved salts. The detailed work of Professor Dittmar[1] (undertaken in connection with the Challenger Expedition) was especially

[1] *Challenger Report*, (Physics and Chemistry) Vol. I.

important in this direction, and indeed almost rendered superfluous any further complete analyses of sea-water—the percentage of total solids only being required.

However, since in the seventy-seven complete analyses of "Challenger" waters there is not included any off the coast of New South Wales,[2] the present analysis was undertaken—at the suggestion of Professor Liversidge and in connection with his investigation on the presence of gold in sea-water—as a check on the theoretical quantities demanded by Dittmar's and Buchanan's calculatious.

The accurate determination of total salts is not quite such a simple matter as at first sight it appears. The apparently most obvious method of evaporating a known quantity of water to dryness is inapplicable, since under these conditions the magnesium chloride is partly decomposed according to the equation

$$MgCl_2 + H_2O = Mg + 2\ HCl.$$

The large excess of alkali chlorides which might be expected to protect the magnesium chloride does not prevent decomposition.

Other methods of determining the total solids which readily suggest themselves are

(1) Determination of specific gravity.

(2) Determination of some important constituent which can be readily estimated with a high degree of accuracy—like chlorine—and multiplying this by a certain constant factor.

The latter method was employed by Dittmar, who, working on total halogen estimated as chlorine, concluded that the constant factor should be 1·8058. The former was adopted by Buchanan who applied it to many hundreds of

[2] Four surface samples (Nos. 444 - 447) were collected on the trip from Melbourne to Sydney, but seemingly were only utilised for specific gravity determinations.

samples during the Challenger's voyage. The specific gravity determinations of the present specimen were made by a hydrometer (No. 6) presented to Professor Liversidge by the designer J. Y. Buchanan, F.R.S. It is of the same type as the particularly sensitive instruments used on the "Challenger" and later on the "Princesse Alice."

Buchanan gives a very instructive account of the use and capabilities of these hydrometers in his "Retrospect of Oceanography,"[1] from which it may be of interest to give the following brief summary.

The instrument is made of glass and is provided with a large cylindrical body (about 200 ccs. in volume) and a very fine stem (about 3·5 mm. in diameter). In the manufacture the hydrometer is so weighted that at 30°[2] it floats in distilled water up to a certain mark on the stem. To make it float to the same mark in sea-water of the same temperature, extra weights have to be added. The weight of the hydrometer is also the weight of the water it displaces, hence we have the weights of equal volumes of sea and distilled water at the same temperature; the quotient gives the specific gravity of sea-water (referred to distilled water at the same temperature). Stem divisions serve to avoid the use of very small weights. For the sake of convenience the specific gravity is usually expressed as a density relation between sea-water at 15·56° C. and distilled water at 4°. Such a "specific gravity" is denoted by $4^{S}\,15{\cdot}56$.

By means of such an instrument Buchanan claims that the specific gravity of sea-water can be found to ± ·00001. As the salinity varies directly as the density, and the

[1] Reprinted from the "Antarctic Manual," p. 901.

[2] In the instrument used (No. 6) the temperature corresponding to this position of equilibrium was 29·1° C.—probably due to a slight contraction in the body of this hydrometer—analogous to that of the bulb of a thermometer on long standing.

density can be found with such accuracy, it follows that such a form of hydrometer is peculiarly suitable for rapid and accurate sea-water work, especially on board ship, where the extra refined methods of a well equipped laboratory are inapplicable. Moreover, "in a sea-water whose specific gravity is 1·03000, 1 in the fifth place represents $\frac{1}{3000}$ of the total solid contents, so by careful use of the hydrometric method the salinity to one part in 75,000 of water, or differences of 1 grain per gallon can be determined."

Certainly as far as hydrometric work goes, these instruments seem to approach the limit of accuracy and delicacy, yet the most sensitive hydrometer has an inherent defect, *i.e.*, the uncertainty of the exact resting point of the partly submerged instrument, due in part and presumably chiefly to capillarity. In the present case the possible error from this cause was of the order of 1 mm. of the stem. Thus for specially accurate work other methods must be sought.

A practical application of the instrument to the determination of the specific gravity of the Coogee sample will exemplify its method of use.

Vol. of hydrometer to 0 mm. of stem at 22° C. =	185·01384 cc.
Volume of stem to 5 mm.	·05810
Total immersed volume	185·07194

Weight of hydrometer + weights displacing same volume of sea-water at 22° C. =	189·5871 gms.
∴ Weight of 1 cc. at 22° C. ... ... =	1·02445
Tabular correction to reduce to 15·56	·00164
$\therefore\ 4^{S}\ 15{\cdot}56 =$	1·02609

For greatest precision a direct chemical method offers the most satisfactory solution of the problem—such as the

determination of 'chlorine' with the higher degree of accuracy obtainable.

In the present case there is nothing to note about the methods employed to determine the various constituents—old standard methods being used throughout, but great care was taken to obtain as accurate results as possible (*e.g.* weighing amounts of water taken instead of using volume relations etc.)—and thus results capable of comparison with recognised analyses.

The results obtained for the solid contents of the Coogee water, expressed in grams per kilo were as follows:—

				Mean.
Cl	(a)	19·449	19·472 (b)	19·446
Br		·0623		·062
SO_3		2·310	2·290	2·300
CaO		·588	·586	·587
MgO		2·164	2·204	2·184
K_2O		·485	·475	·480
Na_2O... ...		14·600	14·454	14·527

Subtract O equivalent to halogen ... ... $-$ 4·3939

∴ Total salts per kilo (omitting CO_2) = 35·192

(*a*) = 19·477 total halogen estimated as chlorine.
(*b*) = total halogen estimated as Cl.

The theoretical quantity of total salts in gms. per kilo, taking the specific gravity previously found and Dittmar's factor, would be $19·475 \times 1·8058 = 35·267$; subtracting from this the average amount of CO_2 (not estimated in above) as ·051 gms.,[1] we get 35·216 gms. per kilo of sea-water.

[Combining the constituents found in the generally accepted way, and omitting CO_2 we obtain the following results:—

[1] Calculated from Dittmar's table—Challenger Report, (Physics and Chemistry) Vol. I., p. 203.

NaCl	27·370	gms. per kilo.
$MgCl_2$	3·884	"
$MgSO_4$	1·667	"
$CaSO_4$	1·264	"
K_2SO_4	·887	"
$MgBr_2$	·072	"
MgO (by difference) ...	·048	"
Total ...	35·192	"]

Expressing these results in terms of 100 of halogen calculated as chlorine (Dittmar's method) we get the following comparison :—

	Coogee, N.S.W.	Dittmar (Average of 77 analyses)
Cl...	99·858 ...	99·848
Br...	·320 ...	·340
So_3	11·810 ...	11·576
CaO	3·014 ...	3·026
MflO	11·214 ...	11·212
K_2O	2·464 ...	2·405
Ma_2O	74·604 ...	74·462
Oxygen equivalent to Cl.	...	− 12·492

In connection with the above piece of work I wish to express my grateful appreciation of the help and suggestions of Professor Liversidge, F.R.S.

NOTE ON THE EFFECT OF LIME UPON THE AVAILABILITY OF THE SOIL CONSTITUENTS.

By F. B. GUTHRIE, F.I.C., F.C.S., and L. COHEN.

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THE experiment here described was undertaken with the object of determining to what extent the availability of the soil constituents is affected by the addition of lime. Three kinds of soil were used in the experiment, a light sandy soil, a garden loam fairly rich in humus, and a very stiff clay soil. The soils were well mixed, passed through a sieve with 1 millimetre mesh, and about 10 lbs. of each placed in an ordinary 11 inch terra-cotta unglazed pot, closed at the bottom with a cork. Duplicate portions sifted as above were thoroughly mixed with 1% freshly slacked lime and potted in duplicate.

The pots were placed for a month in a position exposed to sun, rain and wind, and kept moist the whole of the time. On three occasions they were saturated with heavy showers but did not overflow. The clay soil which had been treated with lime had undergone considerable physical changes, having become quite friable and easily broken up by the fingers at the end of a fortnight.

At the time of filling the pots, samples of the original soils in an air-dried condition were taken for the determination of the plant-food soluble in hydrochloric acid, citric acid, and water. The analyses are as follow:—

Analyses of Original Soil.

		Clay.	Loam.	Sand.
Soluble in HCl S.G. 1·1	CaO	·742	.827	·109
	K_2O	·241	·103	·031
	P_2O_5	·184	·348	·074

		Clay.		Loam.		Sand.
Soluble in 1% citric acid	K_2O	·0115	...	·0254	...	·0055
	P_2O_5	·0405	...	·1674	...	·0317
Soluble in distilled water	K_2O	·0057	...	·0061	...	·0027
	P_2O_5	·0027	...	·0026	...	·0019

After the pots had stood a month, the soil in each pot was well mixed and all lumps broken up, after which a fair sample was taken without sifting, and dried at air temperature.

For the citric soluble determinations 100 grams of air-dried soil were placed in a Winchester with a litre of one per cent. solution of pure citric acid, the bottle being then fixed in a mechanical shaking apparatus (end over end motion) making approximately 50 revolutions per minute, and shaken continuously for 20 hours. With this solvent it has been shown by A. D. Hall that no further quantity of phosphoric acid or potash goes into solution after that time. The shaking being completed, the Winchester was allowed to stand in an upright position for some hours, after which the clear supernatant liquid was syphoned off and filtered through a dry paper.

Of the clear filtrate 500 cc. were taken and evaporated to dryness with about 50 cc. of nitric acid. The residue was then ignited gently at a low heat, and on cooling taken up with hydrochloric acid, using the molybdate method for P_2O_5, and the platinic chloride method for K_2O.

To obtain the water-soluble extract, 200 grams air-dried soil were shaken in a Winchester with a litre of distilled water for 20 hours in the above described apparatus. After standing for about 6 hours, the clayey liquid was syphoned off and filtered under pressure through a Pasteur filter candle by means of a force pump. 500 cc. of the clear filtrate were evaporated to dryness with a few drops of HNO_3, proceeding in the same manner as for citric soluble. The results of the analyses are given as follows:—

WATER SOLUBLE—(*a*) *Phosphoric acid* P_2O_5.

	Original.	Standing 1 month.	Mean.	Limed 1 month.	Mean.	Increase.
Sand	·0019	·0006	·0007	·0029	·0033	·0026
		·0007		·0037		
Loam	·0026	·0004	·0005	·0022	·0024	·0019
		·0006		·0025		
Clay	·0027	·0008	·0008	·0019	·0019	·0011
		·0007		·0018		

(*b*) *Potash* K_2O.

	Original.	Standing 1 month.	Mean.	Limed 1 month.	Mean.	Increase.
Sand	·0027	·0018	·0019	·0038	·0039	·0020
		·0019		·0039		
Loam	·0061	·0045	·0044	·0048	·0047	·0003
		·0043		·0046		
Clay	·0057	·0007	·0008	·0038	·0034	·0026
		·0009		·0030		

CITRIC SOLUBLE.—(*a*) *Phosphoric acid* P_2O_5.

	Original.	Standing 1 month.	Mean.	Limed 1 month.	Mean.	Mean Increase.	Mean Decrease.
Sand	·0317	·0315	·0309	·0315	·0312	·0003	...
		·0302		·0308			
Loam	·1674	·1860	·1815	·1802	·1792		·0023
		·1770		·1782			
Clay	·0405	·0423	·0426	·0210	·0241		·0185
		·0422		·0272			

(*b*) *Potash* K_2O.

	Original.	Standing 1 month.	Mean.	Limed 1 month.	Mean.	Mean Increase.	Mean Decrease.
Sand	·0055	·0074	·0071	·0087	·0081	·0010	
		·0067		·0074			
Loam	·0254	·0196	·0193	·0221	·0221	·0028	
		·0190		·0221			
Clay	·0115	·0113	·0113	·0118	·0114	·0001	
		·0113		·0110			

The analyses were made in all cases on the air-dried soils. The moisture was determined in each case in order to apply corrections if necessary. No corrections were made as the water-contents were fairly constant, but the figures are given below :—

MOISTURE CONTENT OF SOILS.

	Original.	Standing 1 month.	Limed 1 month.
Clay ...	6·36	8·07	8·94
Loam	3·99	2·02	2·89
Sand ...	1·69	·19	·26

There are one or two points to be noted in these tables. In the first place the amount of mineral plant-food (phosphoric acid and potash) soluble in water has suffered a very considerable decrease during the period of the experiment, notably the water-soluble phosphoric acid in all soils, and the potash in the clay soil.

The action of liming has been in all cases to produce an increase in the quantities of water-soluble plant-food over the unlimed, but it is only in the sandy soil where liming has had the effect of increasing the proportions of water-soluble phosphoric acid and potash above those originally present in the soil.

There was no vegetation in the pots, and no drainage except through the walls of the pots, and the samples for analysis were taken by mixing the whole of the contents of the pots and not from the surface layer only. It would therefore appear that there is a steady loss of water-soluble plant-food during the period, either by percolation through the sides of the pot or by conversion into insoluble plant-food. Whether the lime present prevents this reversion of the water-soluble plant-food, or whether it renders fresh plant-food soluble in water is not shown by this experiment.

In the case of the citric acid soluble ingredients there has been very little appreciable alteration in the quantities after standing, in some cases there has been an actual increase. The effect of liming is much less marked than with the water-soluble plant-food. In the case of the phosphoric acid there is an actual decrease in this constituent, especially in the clay soil. In the case of potash the increase is also much less than with the water-soluble potash, except in the case of the garden loam.

Portions of the unlimed and limed soils were also examined in order to ascertain the effect of lime on the soluble nitrogen. The pots had by this time been standing

eight months in a dry state. The soil was well mixed and a weighed portion shaken for a few minutes with nitrogen free water in the proportion of 1 gram. of soil in 2 cc. water. The extract having been filtered through porcelain under pressure, 2 grammes purified "vegetable black" were added to about 250 cc. and stirred for 20 minutes. The whole was filtered again through a Pasteur candle, the filtrate being then as a rule completely decolorised. In two cases however the treatment with "black" had to be repeated before a perfectly colourless solution was obtainable.

The carbon used for this purpose was the ordinary "vegetable black" of commerce, containing large quantities of paraffin oils. It was purified by heating to redness in a covered crucible, and when cool lixiviating three times with hot nitrogen free water. For the determination of ammonium salts, portion of the filtrate from the soil after decolorisation was nesslerised direct. The nitric nitrogen was determined by the phenolsulphonic acid method and the nitrous by the starch method. The results are given below :—

Nitrite nitrogen in parts per million of soil.

	Unlimed.	Limed.	Increase or Decrease.
Clay ...	·4	3·6	+ 3·2
Loam...	·1	2·0	+ 1·9
Sand ...	nil	·7	+ ·7
	Nitrate nitrogen.		
Clay ...	8·0	5·0	− 3·0
Loam...	4·5	4·5	...
Sand ...	·2	·4	+ ·2

The interesting point about the above figures is the large increase in the proportion of nitrite nitrogen in the limed soils. The total nitrogen as nitrite and nitrate has increased in all cases, and the nitrate nitrogen has remained almost stationary, except in the clay soil. It would not therefore

appear that the production of nitrites is due to any process of denitrification, but rather that under the conditions of the experiment (vegetation being absent and the soil undisturbed) the action of lime is to promote the development of the organisms which convert the ammoniacal soil nitrogen into nitrous acid.

The figures for ammoniacal nitrogen do not throw any light on this point, for the decrease in ammoniacal nitrogen after liming is undoubtedly largely due to loss of ammonia, the limed soils all giving off a distinct odour of the gas. The figures obtained are however given:—

Ammoniacal nitrogen in parts per million of soil.

	Unlimed.	Limed.	Increase or Decrease.
Clay ...	... 8·2	... 1·0	... −7·2
Loam...	... 5·3	... 1·6	... − 3·7
Sand ...	... 5·3	... ·8	... − 4·5

The fact that there has been no loss of the very soluble nitrites and nitrates would indicate that the diminution of water-soluble potash and phosphoric acid previously noted is not due to percolation through the walls of the pots so much as to conversion into less soluble forms.

It is our intention to continue these experiments under conditions which will afford more precise information concerning the various questions involved.

NOTES ON SOME ABORIGINAL TRIBES.

By R. H. MATHEWS, L.S.,

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IN this paper I have supplied some genealogies which have never before been published respecting the intermarrying laws of the aborigines in different parts of the Australian continent. The genealogies referred to, contained in Tables II., IV., and V., are the results of several years' careful inquiry, and it is believed that their accuracy is unassailable. The application of these genealogical tables to the sociology of several tribes is briefly and clearly explained. A few remarks are added on the absence of exogamy among any of the tribes treated in this article.

Since 1895 I have been devoting some attention [illegible] sociology of the Arranda tribe, amongst others, [illegible] Northern Territory. Mr. W. H. Willshire, who [illegible] Alice Springs from 1881 for a number of years, [illegible] region the name of "Central Australia," being a [illegible] and romantic name for his book. That name [illegible] by Spencer and Gillen for the same reason. [illegible] however, no such place as Central Australia [illegible] geographers—that portion of the continent [illegible] our maps as the Northern Territory. I [illegible] visited the country occupied by the [illegible] been fortunate enough to collect much [illegible] persons who went out to the mineral [illegible] of cattle and horse stations, from [illegible] the police and others; all of whom [illegible] district for many years.

I had the subject sufficiently in hand by 1898 to enable me to take the responsibility of communicating a short article to the American Philosophical Society containing the following table of the intermarrying laws of the Arranda tribe,[1] in which I stated that descent was through the females.

Table I.

Cycle.	Wife.	Husband.	Offspring.
A	Purula	Pananka	Bangata
	Ngala	Knuraia	Paltara
	Bangata	Mbitjana	Ngala
	Paltara	Kamara	Purula
B	Pananka	Purula	Kamara
	Knuraia	Ngala	Mbitjana
	Kamara	Paltara	Knuraia
	Mbitjana	Bangata	Pananka

The four women in the column headed "Wife" in the upper half of the table constitute the Cycle A, and have perpetual succession amongst themselves. Purula has a daughter Bangata, who has a daughter Ngala, who has a daughter Paltara, who has a daughter Purula, thus reverting to the commencement of the series. The lower half of the table or Cycle B has exactly the same constitution. This is sufficient evidence that the devolution of the section names is through the women. Every one of the daughters would of course have brothers belonging to the same section name as herself.

Taking the first line in the table, we see that Pananka marries a Purulu woman, who is his tabular or No. I wife, and the offspring is Bangata. But Pananka could instead marry a Ngala woman, as his alternative or No. II spouse. Rev. L. Schulze[2] was the first to report the alternative

[1] Proc. Amer. Philos. Soc., xxxviii., p. 76, table I.
[2] Trans. Roy. Soc., S. Aust., xiv., 223 – 227.

marriages among the Arranda. Mr. Schulze, however, arrived at the conclusion that descent was paternal, and the same opinion was subsequently adopted by Spencer and Gillen in their book dealing with the natives of that district.[1] With the view of throwing additional light upon the disputed question of succession, I obtained from one of my most capable correspondents, residing in that locality, the names of more than a dozen married pairs, with their pedigrees, reaching back one generation, and forward one generation, from which I have taken at random the four couples given in the following table. In these four cases, each man is married to a tabular or No. I wife :—

Table II.

Father of Individual Section.	Mother of Individual Section.	Individual answering the Questions.			Child of Individual. Section.
		No.	Proper Name.	Section.	
Ngala	Knuraia	1	Paul	Mbitjana	Ngala
Pananka	Purula	1A	Helena	Bangata	
Paltara	Kamara	2	Moses	Knuraia	Paltara
Mbitjana	Bangata	2A	Sophia	Ngala	
Knuraia	Ngala	3	Peter	Paltara	Knuraia
Purula	Pananka	3A	Rebecca	Kamara	
Pananka	Purula	4	Nathaniel	Bangata	Pananka
Ngala	Knuraia	4A	Maria	Mbitjana	

An explanation of one of the married couples in the above table will answer for all the rest. I have given the English name of each person, so that they can be easily found and further interrogated. No. 1, Paul, a Mbitjana, marries Helena, No. 1A, a Bangata, and their children are Ngala. On the same line and to the left of Paul, we find Knuraia, the section of his mother; and a little farther to the left, in the next column, is Ngala, the section to which Paul's father belongs. Taking No. 1A we find that Helena's

[1] Native Tribes of Central Australia, p. 70.

mother was Purula and her father Pananka. We have, therefore three generations on the same line across the page, the parents, the grand-parents and the children. We also observe that the sections of each married pair, the sections of their parents, and the section name of the progeny are exactly in accord with Table I. If we had selected a list of men who had married alternative or No. II wives, the details would have been different.[1]

When the Arranda people are in camp, the fathers and sons will have their resting places near each other, because the sons belong to their father's tribe and inherit their father's hunting grounds. For example, the Pananka and Bangata men will be close together; the Purula and Kamara men will also be near one another; and so on for all the men of the other sections who stand in the relationship of fathers and sons. This fact has caused superficial observers to believe that the sections which camp together in this way are those belonging to the same cycle or phratry.

Just the contrary is the fact—the fathers and the sons belong to opposite phratries or cycles, although they belong to the same local division of the tribe and frequently roam about together.

In order to further test the line of descent among tribes possessing eight subdivisions, I requested another competent correspondent to obtain genealogies of several married pairs in the Chingalee tribe about Powell's Creek and Daly Waters. To enable us to understand the genealogies, it will be necessary to tabulate the eight intermarrying sections, first published by me in 1900 :—[2]

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[1] Compare with table on p. 72, Vol. xxxii., this Journal.

[2] American Anthropologist, II., N.S., 495, with map. The full form of most of the section names has the termination *inja*, as Chungaleeinja, Chulainja, and so on, but this common ending is omitted in Table III.

Table III.

Cycle.	Wife.	Husband.	Offspring.
A	Chungalee	Chimitcha	Taralee
	Chula	Chuna	Tungaree
	Taralee	Chemara	Chula
	Tungaree	Champina	Chungalee
B	Chimitcha	Chungalee	Champina
	Chuna	Chula	Chemara
	Champina	Tungaree	Chuna
	Chemara	Taralee	Chimitcha

The above table shows that the tribe is classified into two cycles or phratries A and B, like the Arranda, each cycle containing four sections. The women of a cycle, A for example, have perpetual succession in a prescribed order the same as the Arranda. Every woman has brothers of the same section as herself.

If we take the first name in the table, it will serve as an illustration of all the others. Chimitcha's "tabular" or normal wife is Chungalee, whom we shall call No. I. He can in certain cases marry Chula, whom we have denominated his "alternative" wife or No. II. Or he can take a Chuna woman, distinguished as No. III. And further, Chimitcha may espouse a Chimitcha maiden, whom we shall set down as his No. IV wife. Looking at the table we observe that two of Chimitcha's possible wives belong to Cycle B and two to Cycle A, and it is manifest that the denomination of his children will depend upon the woman he takes for his wife.

In further explanation of Table III., a woman may likewise be alloted a partner from any one of four sections, two of whom belong to the opposite cycle and two to her own. Chungalee the first woman in the table may marry Chimitcha as her No. I husband, Chuna as No. II, or Chula as No. III,

or Chimitcha as No. IV. But it is immaterial to the descent of the offspring which of these men she marries; her children are Taralee just the same, because the devolution of the sections as well as of the cycles is unalterably through the mother only.

From a list supplying the details of upwards of twenty marriages among members of the Chingalee tribe, personally known to my correspondent, I have selected the following eight individuals or four married pairs as examples

Table IV.

Father of Individual. Section.	Mother of Individual. Section.	Individual answering the Questions. No.	Proper Name.	Section.	Child of Individual. Section.
Champina	Tungaree	1	Long Dick	Chungalee	Tungaree
Tungaree	Taralee	1A	Minnie	Chula	
Champina	Tungaree	2	Lg.Tommy	Chungalee	No family
Tungaree	Chemara	2A	His wife	Chimitcha	
Chimitcha	Chungalee	3	Harry	Taralee	Chimitcha
Chula	Chuna	3A	First wife	Chemara	
Chimitcha	Chuna	3B	Second ,,	Chemara	
Tungaree	Champina	4	Jacob	Chuna	No family
Taralee	Champina	4A	Daisy	Chuna	

This table is the same in structure as Table II. No. 1, Long Dick, a Chungalee, marries No. 1A, Minnie, a Chula, and their children are Tungaree. On the same line to the left of Dick we find Tungaree, the name of his mother's section. And in the next column to the left is Champina, the section to which Dick's father belongs, and so on for all the rest. In comparing this table with Table III, we discover that Nos. 2 and 3 are married to the normal or tabular wives. No. 1 has a No. III wife, whilst No. 4 has a spouse of the No. IV type. Again, the fathers of Nos. 1A and 3B have No. III wives. The fathers of Nos. 2A and 4A have No. II wives. It may be mentioned that Table IV,

although nominally dealing with four married pairs, actually gives the section names of twelve men, as well as the sections to which their wives belong. The same remark applies to Table II, *ante*.

Although I have occasionally collected lists of native words for different degrees of relationship, I have not yet published any of them. There are generally so many different persons who could come under any given name, that a list would not be of much value other than as a vocabulary. For example, a man's father, mother's father, father's father, son's wife. daughter's husband, etc., could belong to any one of four sections. Unless we first of all have the section name, we cannot identify the division of any one of the people just mentioned, by their so called "relationship terms." These terms do not define either kinship or consanguinity.

In the same way there are many other names of kindred whose section names differ with the man or woman the individual has married. To hear one man address another gives no definite idea of either the cycle or the section to which the person addressed belongs. In the Chingalee tribe a man's father is Keeta.[1] Looking at Table IV, if we take No. 1A, Minnie, a Chula, we see that her father, whom she speaks of as *keeta*, instead ef being Chemara as in Table III, is actually Tungaree, a man of the opposite cycle to Chemara.

With regard to the well known sexual license which is permitted at important native ceremonies all over Australia, I requested some of my correspondents in the Northern Territory to obtain the names of the sections of the men who participated.[2] The result was that in most

[1] Queensland Geographical Journal, XVI., (1901), p. 87, in my Vocabulary of Chingalee words.

[2] Queensland Geographical Journal, XX., 68.

cases the women whose favours were obtained by a given man, belonged to the sections from which he could claim a No. 1, 2, 3 or 4 wife. Exceptions were of course observed as we should expect, judging by the variations in other native rules. I notice that Spencer and Gillen[1] in reporting cases of sexual liberties of this kind, give examples which would mostly fall respectively within the scope of Nos. 1, 2, 3 and 4 marriages. The authors were not aware of the Nos. 3 and 4 types of marriage, but certain women whom they mention answer the description.

Anyone advocating paternal descent among the Chingalee might perhaps lay stress upon the fact that the child is always assigned the section name of its father's father. There is, however, no weight at all in that argument, because the very same thing happens in the Kamilaroi, Wiradjuri, Barkunjee, etc., where the descent is unmistakably through the mother only. Not only so, but in every tribe I know possessing female descent all over Australia, the child takes the section name of its father's father. This law holds good no matter whether the tribe be divided into two, or four, or eight intermarrying sections.

In former articles I have described the social organisation of the Barkunjee[2] and Kamilaroi tribes. It will be interesting to show the resemblance of the social structure of these tribes to that of the Chingalee and Arranda. In the Barkunjee there are only two principal divisions—the cycles—and the name of the offspring is determined through the women. The men of one cycle marry the women of the opposite one or else the women of their own cycle, which is tantamount to the statement that the aggregate of men in one cycle can marry all the women of the tribe.

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[1] Northern Tribes, 134 – 136 and 138 – 139.

[2] This Journal, xxxix., 118.

Then comes the Kamilaroi organisation with two partitions of each cycle.[1] The men may marry into the opposite cycle or else into their own, while the cycle and section name of the progeny is in all cases regulated through the mothers. In other words, the men of one cycle, taken collectively, can marry into all the divisions of the tribe.

Next we take the Chingalee people, Table III, and find that the community is segregated into two cycles just as in the Barkunjee, but each cycle contains four parts instead of one. The men of a cycle can marry into the opposite one or into their own and the section names of the offspring are fixed through the females. Therefore the men of one cycle collectively can intermarry with all the women of the community.

From what has been said, the conclusion seems inevitable that the social structure of the Barkunjee, Kamilaroi and Chingalee is essentially and radically the same in all its leading elements. The chief or only difference is that in the two first named the totems have succession through the mothers, whilst in the latter their succession does not depend upon either parent, but is fixed by the locality where the mother first became conscious that conception had occurred. In previous articles[2] I have described the native belief in regard to this matter and will only briefly allude to it here.

The component parts of a tribe having this form of organisation are in many respects similar to the Kamilaroi. For example, there is a local division of a tribe, in which there are persons bearing the totem names of animals, trees, the elements, etc. People whose totems may belong to any or all of these departments of the universe roam about

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[1] American Antiquarian, XXVIII., 85, 86.
[2] This Journal, XL., 110.

together, or at any rate fraternize when they meet in any part of their common territory. There are certain spots scattered up and down at short intervals in this territory which are traditionally haunted, some by one animal or object and some by another, from which the children receive their totemic names instead of from the mother. It appears then that, like the Kamilaroi, the totems are dispersed throughout the tribal hunting grounds, but are allotted to the offspring according to the locality of conception instead of parentage.

In the greater part of New South Wales descent of the totems is counted through the mother. A totemic clan or group possesses a more or less extensive tract of country which all the members of the clan occupy as their common birthright. The hunting grounds of every Australian tribe, and consequently of all the partitions and repartitions of the tribe, descend from the fathers to the sons for ever. The children of every marriage belong to the father's tribe, no matter whether the totems descend through the mothers or the fathers, or are acquired by the accident of conception. Among the Chingalee, Arranda, Wombaia, and other tribes there are similar tracts of country occupied by totemic clans or groups, but instead of taking the totem from the mother, this matter as already stated is determined by locality. In other words, the totems, instead of being inherited from living subjects scattered over their hunting grounds, are obtained from certain hills, trees, rocks, etc., similarly scattered at random throughout the ancestral territory.

Again, in all Australian tribes, whether the descent of the children is maternal or paternal, or acquired by accident, the privilege of working incantations, making rain, performing initiatory ceremonies and other important functions, descends from the men of the tribe to the sons. This

law is the same in the Kamilaroi, Wiradjuri, Chingalee, Arranda, and other tribes, and is no evidence of paternal descent. Moreover, all the ceremonies in connection with the totems are likewise handed down through the men, quite irrespective of how the totems descend. In summarizing the social laws of the aborigines, whether in the Northern Territory, New South Wales, or in the other States, we discover that although they vary in all sorts of details yet they agree in the main lines of their organisation.

In 1904 I contributed an article to this Society containing a brief account of the sociology of the Ngēumba tribe, in which I reported the existence of certain castes, which I provisionally named Blood and Shade divisions.[1] In order to obtain the bearing of these castes on the social organisation it was necessary to prepare the pedigrees of several families to illustrate the laws of intermarriage among them, as well as the descent of the castes to the progeny. I did not at the time publish these genealogies because I had quite sufficient information to satisfy myself, and thought it unnecessary to do any more. Since the publication of my article and its circulation amongst the anthropologists of England, some of them have asked me to publish some of these genealogies so that the people of England and elsewhere may have a chance of forming their own conclusions from my observed facts. I am therefore now submitting one of the genealogies for publication.

Before proceeding with the annexed table the reader is invited to peruse my former article which describes the division of the Ngēumba tribe into cycles, sections, and totemic families, with explanatory examples. Besides the divisions just mentioned and quite independently of them, there is another bisection of the community into Guaigulir or active blood, and Guaimundhun or sluggish blood. There

[1] This Journal, XXXVIII., 209, seq.

is still another partition of the community into Nhurrai, the shade cast by the butt or lower portion of a tree and Winggu, the shade thrown by the higher branches. The Shades are apparently an extension of the Blood divisions, and regulate the camping of the people under umbrageous trees. A Guaigulir is always a Winggu and a Guaimundhun is always a Nhurrai.

The castes of Blood and Shade are not necessarily coincident with the other divisions. For example, each cycle, every section and every totemic group contains people belonging to the Guaigulir and Guaimundhun Bloods with their corresponding Shades. Then as regards the descent, a Guaigulir mother has a Guaigulir family of the Winggu Shade, and a Guaimundhun mother's children inherit her Blood and Shade nomenclature; just in the same way that the children of a woman of the Bandicoot totem are Bandicoots like herself.

I shall now tabulate the pedigrees of ten couples or twenty married persons belonging to the southern portion of the Ngēumba territory. Every one of these individuals was examined by myself and I am supplying the names of my native informants.

Examining the following table, we find the person we are dealing with whom we have called the "Individual," in the central column. No. 1, Jack Onze, of the section Ippai, and a Guaigulir. No. 1A, Nellie his wife, a Matha and a Guaimundhun, contracted to G'dhun to make it fit into the narrow column. I have not encumbered the table with Shades, because in every instance yet met with a Guaigulir is a Winggu and a Guaimundhun a Nhurrai. In the next column to the right of Jack and Nellie is their child, a Kubbi, who has the same Blood and Shade as his mother Nellie. On the left of No. 1 is Jack Onze's mother, an Ippatha and of the same blood as himself. In the extreme

Table V.

Father of Individual.		Mother of Individual.		Individual Answering the Questions.				Child of Individual.	
Section.	Blood.	Section.	Blood.	No.	Proper Name.	Section.	Blood.	Section.	Blood.
Murri	G'dhun	Ippatha	Guaigulir	1	Jack Onze	Ippai	Guaigulir	Kubbi	G'dhun
Kumbo	G'dhun	Kubbitha	G'dhun	1A	Nellie Onze	Matha	G'dhun		
Murri	Guaigulir	Butha	G'dhun	2	Tom Draper	Ippai	G'dhun	Kubbi	G'dhun
Kumbo	G'dhun	Kubbitha	G'dhun	2A	Nanny Draper	Matha	G'dhun		
Murri	Guaigulir	Butha	Guaigulir	3	Jack Charlton	Ippai	Guaigulir	Murri	G'dhun
Kumbo	G'dhun	Matha	G'dhun	3A	Mary Charlton	Kubbitha	G'dhun		
Murri	G'dhun	Butha	G'dhun	4	Tom Keegan	Ippai	G'dhun	Kubbi	G'dhun
Kumbo	Guaigulir	Kubbitha	G'dhun	4A	Norah Keegan	Matha	G'dhun		
	Unobtain	able		5	Jack Trap	Kumbo	Guaigulir	Murri	Guaigulir
Ippai	G'dhun	Matha	Guaigulir	5A	Kitty Trap	Kubbitha	Guaigulir		
Kumbo	G'dhun	Kubbitha	G'dhun	6	Billy Coleman	Murri	G'dhun	Kubbi	Guaigulir
Kumbo	G'dhun	Kubbitha	Guaigulir	6A	Maryann Coleman	Matha	Guaigulir		
Kumbo	Guaigulir	Matha	Guaigulir	7	Steve Shaw	Kubbi	Guaigulir	Kubbi	G'dhun
Ippai	G'dhun	Kubbitha	G'dhun	7A	Susie Shaw	Matha	G'dhun		
Kumbo	G'dhun	Matha	Guaigulir	8	Harry Sheppard	Kubbi	Guaigulir	Murri	G'dhun
Ippai	G'dhun	Matha	G'dhun	8A	Nellie Sheppard	Kubbitha	G'dhun		
Ippai	G'dhun	Matha	Guaigulir	9	Jack Sheppard	Kubbi	Guaigulir	Kumbo	G'dhun
Murri	G'dhun	Butha	G'dhun	9A	Fanny Sheppard	Ippatha	G'dhun		
Kumbo	Guaigulir	Kubbitha	G'dhun	10	Jack Murray	Murri	G'dhun	Kumbo	Guaigulir
Kubbi	Guaigulir	Butha	Guaigulir	10A	Judy Murray	Ippatha	Guaguilir		

left hand column is Jack Onze's father, a Guaimundhun. All the other married pairs can be followed out at sight in the same manner.

It will be seen by Table V that although most of the marriages are normal or mixed Blood, as Guaigulir to Guaimundhun, there are some which are irregular or the same Blood, as Guaigulir to Guaigulir. We also notice examples of the wellknown variations in the intermarriages of the sections, such as in one case Murri marries Ippatha, in another Butha, and in another Matha. Other examples show that Kubbi espouses Butha or Matha, or Ippatha or Kubbitha. The examples likewise disclose the fact that members of the Guaigulir and Guaimundhun Bloods, with their corresponding Shades, are found indiscriminately in all the four sections and consequently in both the cycles.

I have not supplied the totems of the parties in the table because their succession is invariably through the mother. None of the old blacks could give me any reason for the blood and shade castes any more than they can assign a reason for the divisions into cycles or sections, or for the origin of the totems. The natives say that all Guaigulir folk are friendly among themselves and the Guaimundhun people have the same mutual bond of friendship, much in the way that totem kins acknowledge a common tie. The Ippai and Kumbo people of both sexes belong to the Ngurrawun cycle, whilst the Murri and Kubbi folk belong to the Mumbun division.[1]

If we take a given number of natives, say thirty for example, and classify them according to their cycles into separate lots of Ngurrawun and Mumbun, then each lot will contain people of the Guaigulir and Guaimundhun bloods. Or, if we arrange the thirty men according to

[1] This Journal, xxxviii., 207.

their bloods into two lots of Guaigulir and Guaimundhun, then each lot will contain representatives of the Ngurrawun and Mumbun cycles. Not only are the cycles and bloods inextricably mixed up, but there is no exogamy in either of these systems of division.

The facts set forth in the foregoing pages incidentally raise the question whether exogamy has a place in the social structure of the Australian aborigines. It is impossible to bisect a tribe in such a way that the two parts shall be quite independent, so that the men of one part or cycle shall marry the women of the other cycle, and such women only. In dealing with the tribes in the Northern Territory a few pages back we classified the community into two cycles, because there are two sets of women, each set comprising four sections, with perpetual succession in a certain rotation.

The daughters belong to the same cycle as their mothers and become the wives of the men of their father's cycle. The brothers of these girls, who also belong to their mother's cycle, in like manner become the husbands of the women of their father's cycle. These rules however, only hold good for what we have distinguished as No. I and No. II wives. When we come to No. III and No. IV wives or husbands, they are taken from the other cycle (see p. 71, *ante*). Hence our Table III is not an example of exogamy.

When Spencer and Gillen reported the divisions of the Chingalee in 1904,[1] four years after the publication of my Table III, they came to the conclusion that descent was counted through the men, and prepared a table to the following effect. I am using my own spelling of the section names for the sake of uniformity.

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[1] Northern Tribes of Central Australia, p. 100.

Table VI.

Phratry.	Wife.	Husband.	Offspring.
A	Chungalee	Chimitcha	Taralee
	Chula	Chuna	Tungaree
	Champina	Tungaree	Chuna
	Chemara	Taralee	Chimitcha
B	Chimitcha	Chungalee	Champina
	Chuna	Chula	Chemara
	Taralee	Chemara	Chula
	Tungaree	Champina	Chungalee

In the above table each of my cycles of women (see the "wife" column of Table III) is bisected, and the men of a cycle are similarly divided. We will now deal with Phratry A as it appears in Table VI. Taking the first man in the "Husband" column, Chimitcha, we see that his son is Taralee, who belongs to the same phratry as his father. Taralee marries Chemara, a woman of his mother's phratry. This classification is diametrically opposite to my report. But when we look for Chimitcha's No. III wife Chuna and his No. IV spouse Chimitcha, they are found in Phratry B. Then Table VI does not exhibit an exogamous division any more than Table III does. I cannot understand why Spencer and Gillen bisect the cycle or series of women, Chungalee, Chula, Taralee and Tungaree, given as A in the "Wife" column of Table III, and also the corresponding series shown as B in that table, because nothing seems to be gained by it. It neither establishes exogamy nor proves descent of the sections through the fathers.

Looking at Table VI it is seen that if Chimitcha marries Chungalee his children will be Taralee; if he takes a Chula wife they will be Tungaree; if he be allotted a Chuna they will be Chemara; and if he weds a Chimitcha his family will be Champina. The devolution of the sections must consequently depend upon the mothers only. Moreover,

two of Chimitcha's possible wives and two of his possible families belong to one phratry and two of his possible wives and families to the other phratry. There cannot therefore be any partition of the community into two exogamous moieties.

Another point of interest in the sociology of the Chingalee tribe, which has escaped the notice of other investigators, consists of the fact that there are two sets of names for the sections—one set being used from birth to puberty and another set which is adopted from puberty onward through life. The first may be distinguished as the "temporary" and the second as the "final" nomenclature. That is, the section name of every male and every female who has passed through the ceremonies connected with the attainment of puberty is amended or changed altogether.

Looking at Table III of this article, a few examples will be given. The "final" section name Chimitcha is known as Chukaday from birth to puberty; Champachina as Tampalilly; Chungalee as Chukala; Taralee is known as Tapala, and so on for the rest.

I have also discovered two sets of names among the Inchalanchee tribe in the north-west district of Queensland. Referring to the table published in this Journal in 1898, Vol. XXXII., pp. 251 - 252, the following are a few of the "temporary" forms of the section names given in that table. From birth to puberty Narachee is used instead of Burralanjee; Boonongoona instead of Kommeranjee; Warkee instead of Narrabalanjee; Thimmermill is the temporary form of Yakamurri, etc. In Western Australia there are similar double forms of the section names.

For the purpose of showing that the descent of the totems does not follow the father in the Chingalee, Warramonga, Binbingha and adjacent tribes, I have tabulated a list of Chingalee natives with whom my correspondents are

personally acquainted, and have given their English names by which they are known to the European residents of the district.

Table VII.

Individual's Father.	Individual's Mother.	Individuals answering the Questions.		
Totem.	Totem.	No	Proper Name.	Totem.
Black-striped snake	Fish	1	Charlie	Black-striped snake
Turkey and wallaby	Wallaby	2	David	Turkey
Sterculia	Native bee	3	Lucy	Native bee
Sterculia	Iguana	4	Jack	Iguana
Iguana	Iguana	5	Jumbuck	Water snake
Pigeon	Snake	6	Micky	Iguana
Wallaby	Sterculia	7	Mary	Sterculia and wallaby
Sulky snake	Sulky snake	8	Jim Miller	Sulky snake

Entering the above table we find No. 1, Charlie, whose totem is the black-striped snake. To the left of No. 1 is his mother of the fish totem; and still further to the left is his father, a black-striped snake the same as Charlie. No. 2 also takes his father's totem. Nos. 3 and 4 have the totem of their mother. Nos. 5 and 6 do not follow either parent. Nos. 7 and 8 have the totems of both parents. This table therefore demonstrates that the totems do not uniformly follow the father.

Spencer and Gillen state that "in the Warramunga, Chingalee, etc., the totems are divided between the two moieties, with the result that a man must marry a woman of some other totem than his own."[1] Some of my most capable correspondents who have resided a number of years in the region occupied by the various branches of the Chingalee tribe, have supplied me with comprehensive lists of the totems for three generations. Examination of these lists shows that the black-striped snake and the sleepy lizard are claimed by individuals in the Tungaree, Chuna and Champina sections. The wallaby appears in the Chuna, Tungaree, Champina and Chungalee sections. Honey bee

[1] Northern Tribes of Central Australia, p. 170.

is found in the Chula, Chuna and Chemara sections. The iguana is a totem in the Taralee, Chula, Champina, Chuna and Tungaree sections.

If we compare these examples with my bisection of the Chingalee tribe, Table III, or with Spencer and Gillen's bisection, Table VI, we discover that the totems are scattered up and down in both moieties. Moreover, if we look again at Table VII we observe that the father and the mother of No. 5 both have the same species of animal for their totem. The father and mother of No. 8 are likewise both of the same totem. It is erroneous therefore, to state that the totems are divided into two groups or cycles; and the assertion that a man never marries a woman of his own totem is equally in error.

Spencer and Gillen in dealing with the Warramunga, Chingalee and Binbingha tribes, have reported that the descent of the phratries (cycles) as well as of the sections is determined through the men; that the descent of the totems is almost without exception in the paternal line; and that the totems are markedly divided into two groups.[1] It is hoped that the facts which I have set forth in the preceding pages have made the following facts sufficiently conspicuous: (1) That the sections devolve through the mother only. (2) That the cycles (or phratries) also have descent through the women. (3) That the descent of the totems is not in the paternal line, but follows the same rules which I formerly explained in regard to the Chauan tribe.[2] (4) That the totems are not divided into two groups but are to be found in both parts of every possible bisection of a tribe. (5) And that a man can occasionally marry a a woman of his own totem.

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[1] *Loc. cit.*, pp. 163 and 166.
[2] This Journal, XL., pp. 105 - 111.

In the foregoing pages we have been dealing with tribes containing eight sections in their organisation, and it is thought that a brief review of a tribe comprising only four sections may further enable the student of Australian ethnology to more readily grasp the subject. The following table exhibits the constitution of the Kamilaroi, Ngēumba and kindred tribes. The feminine forms of the section names are omitted.

Table VIII.

Cycle.	Wife.	Husband.	Offspring.
A	Kumbo	Murri	Ippai
	Ippai	Kubbi	Kumbo
B	Murri	Kumbo	Kubbi
	Kubbi	Ippai	Murri

In this table the women of the tribe are classified into two cycles which reproduce themselves for ever, just the same as in the Chingalee, Binbingha, Warramonga and other tribes, except that there are only two sections in a cycle instead of four. It is unnecessary to explain how the cycles, and the sections have descent through the women and that there is an absence of absolute exogamy, because all this has been abundantly illustrated by me in other publications.[1]

But if we bisect the cycles of women the same as Spencer and Gillen have bisected the cycles of the women in the Chingalee, etc., we get the following table:

Table IX.

Cycle.	Wife.	Husband.	Offspring.
A	Kumbo	Murri.	Ippai
	Kubbi	Ippai	Murri
B	Murri	Kumbo	Kubbi
	Ippai	Kubbi	Kumbo

In this rearrangement of the sections in the table, we have taken half the women in Cycle A, Table VIII, namely

[1] This Journal, xxxix., 116, 117; American Antiquarian, xxviii., 86.

Kumbo, and half the women of Cycle B, namely Kubbi, and with them have constructed Cycle A of Table IX. Taking the first man in the "Husband" column, Murri, we see that his son is Ippai, who belongs to the same cycle as his father. Ippai marries Kubbi, a woman of his mother's cycle, A. And when we look for Murri's No. III and No. IV wives they are found in Cycle B.

Further study of Table IX would reveal to us the remorseless fact that quite regardless of the cycle or the section from which Murri gets his wife, the descent of the cycle and the section of his offspring is determined by their mother. It is also manifest that notwithstanding our repeated attempts to divide a tribe into two such parts, that the men of one part shall marry the women of the other part, and such women only, the conclusion forces itself upon us that there is no absolute law of exogamy which answers the conditions.

CORRECTIONS.

In my article on "Sociology of Some Australian Tribes," in Vol. XXXIX., of this Journal, the reader is asked to make the following corrections:—

Page 120, line 25, for Butha read Ippatha.

In lines 28 and 29, same page, transpose the words Ippatha and Butha.

In a table published by me at p. 84 in Vol. XXXII. of this Journal, respecting the sociology of the Koogobathy tribe on the Mitchell River, Northern Queensland, some errors were made, and I wish to substitute the following correct table:—

Husband.	Wife.	Offspring.
Jury	Barry	Mungilly
Ararey	Mungilly	Barry
Barry	Jury	Ararey
Mungilly	Ararey	Jury

In the Koogobathy tribe, the descent of the children is in all cases through the mothers.

THE ONE-WHEELED CAR.

By Lawrence Hargrave.

[*Read before the Royal Society of N. S. Wales, September 4, 1907.*]

It is the special privilege of members of this Society to have a journal as a sort of bank in which they can safely deposit ideas of a more or less bizarre nature, which when first presented appear ridiculous, but when printed and circulated have a way of being first looked into and examined critically by the most remote people, and their merits recognised and acted on. Then, it may be after many years, the invention, or an application of well known laws, is brought to its place of origin as a valuable foreign production. This being the unalterable way in which humanity is built, must be accepted without demur. The particular idea that is here described is a method of simplifying land locomotion by making one wheel suffice where two or more have previously been used.

After many millions of boys had spun and whipped tops, it was discovered that when the top is spun in fixed bearings in a surrounding cage, the top and cage will remain in any position, apparently defying gravity. This is the gyroscope, and after thousands of men had spun gyroscopes, one man substituted a torpedo for the cage and span the top with its axis coinciding with that of the torpedo; thus, as in the Howell torpedo, combining motor and rudder. The Howell torpedo was quite old when Schlick put the top with the axis vertical and a torpedo boat for a cage, thus practically preventing the boat from rolling. Then Brennan span his tops on horizontal axes on a mono-rail car, and found that it would not capsize: and now I want you to see that there is a great advantage in spinning the top on

a car with one wheel only; and that by so doing, any country not precipitous can be negotiated by a motor car so fitted, the car being always on an even keel.

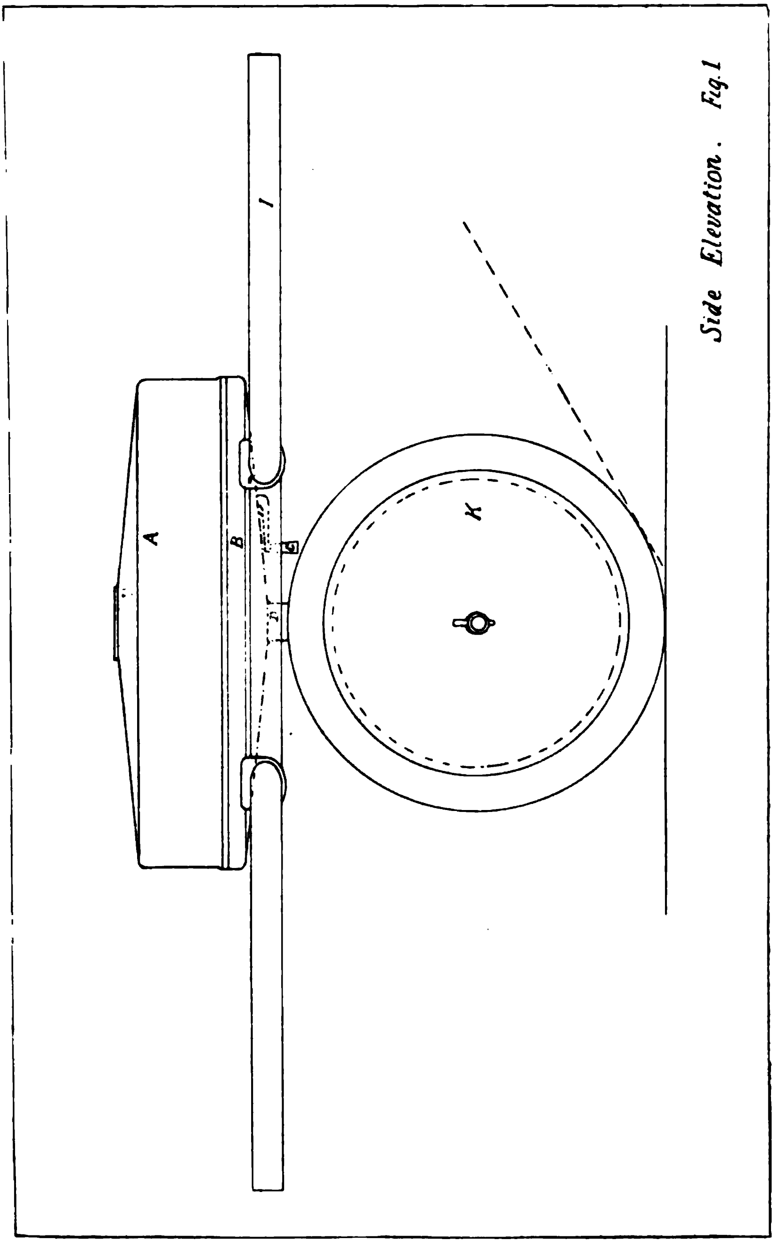
On the English principle that if it is possible to make one part have two or more functions, it is good mechanics to *combine the top and motor*. You are therefore, referred to Plate V., Vol. XXIII., 1889, Plate III., Vol. XXIV., 1890, and figures 3, 4, pages 62, 63, Vol. XXXII., 1898, of our Society's Journal for samples of motors in which the cylinders revolve on fixed crank shafts instead of using the ordinary method of fixing the cylinders and rotating the crank shaft. There are many ways of arranging radial cylinders and vertical shafts, but in all of them the cylinders act as a powerful gyroscope at right angles to the shafts, and the pistons and rods gyro on the crank pins. The two-stroke oil motor is particularly suitable for a gyro-engine, the speed of rotation removing several air cooling and lubricating difficulties.

The power may be taken from the gyro-engine to the tired wheel either by the friction pulley and disc, or by the worm gear as in the models. The friction method is best, as any momentary obstruction on the road automatically compresses the spring, reducing the ratio of the disc to the pulley. The axis of the tired wheel need not be immediately under the axis of the motor; it may be anywhere to suit the requirements of the weights to be carried. The friction gear is remarkably good for starting or stopping the car. For very high speed of engines the worm gear and friction gear may be combined. The model shows that the least touch on the ground by any point other than the tread of the wheel, serves to slue the plane of the tired wheel in the direction it is wished to go. A fan rudder may also be used.

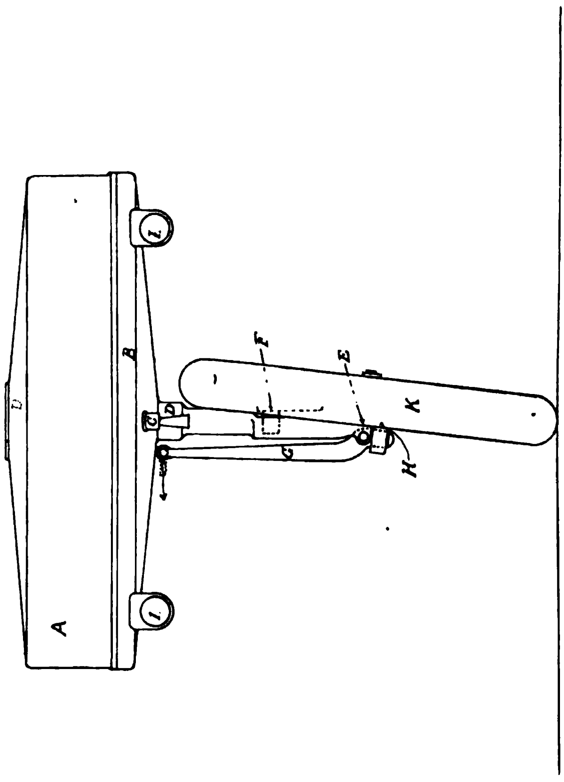
Some of the members will see the one-wheeled car in their mind's eye without any more description, but Figs. 1, 2. 3, have been made from the full sized drawing, so that those who do not understand English may also participate in the knowledge this paper is meant to convey; in particular French and German readers. No sizes have been marked, it being sufficient to state that the tire is 24 inches outside diameter.

The upper casing A lifts off with the fixed crank shaft attached, and the engine and gyro-wheel loose on the upper bearing. The gyro-wheel then unscrews from its fastenings to the cylinder and crank case. The split bearings are then taken apart, releasing the lower spindle and allowing the piston to be withdrawn. The washer on the end of the crank pin being removed, the rod, piston, and piston counter balance lift off. Then the half piston pin is unscrewed and the whole thing is on the floor as we say.

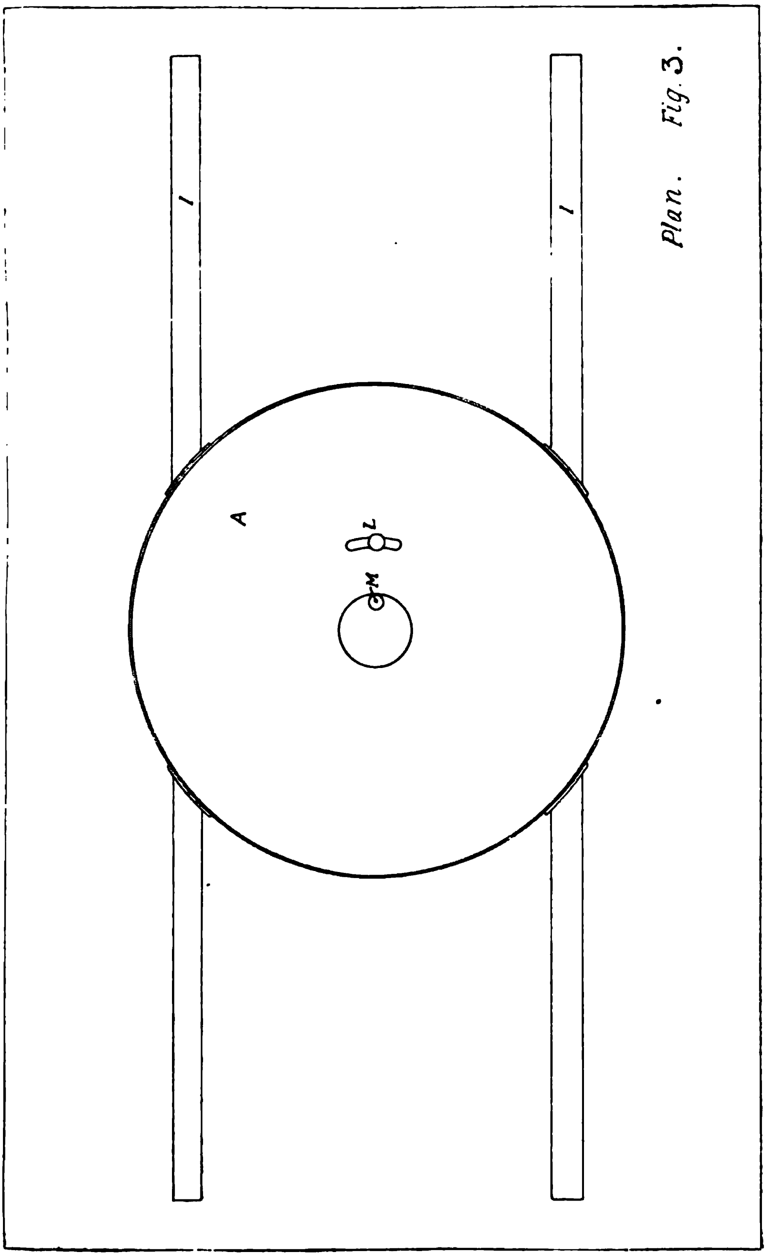
The engine is a short stroke valveless Koerting engine, the fresh air admission is shown, but I think it an unnecessary refinement at this stage. The crank chamber is cylindrical, and a continuation of the cylinder with provision to alter its volume and adjust its weight to that of the cylinder and its parts. The end flanges are turned on the main bearing centres to fit the inner diameter of the gyro-wheel. The gyro-wheel is made of two truncated cones with the smaller diameters screwed together and to the cylinder flanges, the larger diameters hook over the steel channelled wheel which is wrapped and loaded with piano wire or gun tape. The lower spindle sits on balls at E. The friction pulley may slide on a feather on the lower spindle so as to alter the ratio of the gear. The friction disc is shown dotted at F. The cranking handle C is on the bottom casing, and the gyro engine is started before the lever G permits the tired wheel to slide up its



Side Elevation. Fig. 1



End Elevation Fig 2.



Plan. Fig. 3.

sloping axle bringing the disc in gear with the friction pulley; this cannot be done till the gyro sleeps with the load on board. The lower end of the lever is provided with a roller H that bears against the side of the wheel hub. The framing I is two parallel tubes secured to the underside of the lower casing B, and will accommodate four bike saddles. The wheel K is spokeless and has two pressed discs and a 3 inch tire. The spark shifter L, is at a distance from the centre corresponding with the explosion end of the cylinder. The carburetter is attached at M.

Figs. 1, 2, 3, show a car with its centre of gravity practically plumbing the tread of the tire. In this type, if the wheel is put too suddenly into gear, the casing and attachment may start spinning without revolving the wheel. The lubricant, if excessive, will collect in the cup of the piston and end of the crank chamber and cause a disturbance of the balance of parts. A small force pump inside the crank chamber worked off or through the main crank pin can be used to remove the excess if an endurance test is on. When the engine is stopped the oil can drain off through a cock in the end of the footstep. With practice a good course can be steered when the car is nutating.

The short stroke and large diameter of cylinder facilitate making large ports, as the velocity of admission and exhaust is a limiting factor in the speed of revolution. It is hard to say how short the stroke can be made. I think the ideal rotary oil motor that must come will be like a tossed coin; and similar to the steam engine shown in Figs. 3, 4, pages 62, 63, of this Journal for the year 1898.

The division of the power is a matter of interest. If the car is on a perfect track, little push is required, leaving a large balance to speed up the gyro and carry a large weight. If the car is on a steep and stony hillside, plenty of push is wanted, and some of the live load must walk to leave enough gyro to sleep the remainder.

ON THE COMPOSITION OF THE ASH OF A NEW SOUTH WALES SEA-WEED *ECKLONIA EXASPERATA*, AND THE PERCENTAGE OF IODINE PRESENT.

By C. J. WHITE, B.Sc., Caird Scholar, University of Sydney.

(Communicated by Prof. LIVERSIDGE. LL.D., F.R.S.)

[*Read before the Royal Society of N. S. Wales, December 5, 1906*]

THIS analysis of the ash of a New South Wales sea weed, the first of an intended series, was made in the Chemical Laboratory of the University of Sydney, at the suggestion of Professor Liversidge, to be used in connection with his investigation upon the occurrence of gold in sea-water. It was also intended to test for and estimate the amounts of any of the rarer elements which might be present, but this portion of the work has had to be postponed.

Ecklonia exasperata (Family Laminariaceæ, Sub-class Phæophyceæ) is a very characteristic New South Wales Alga—being in fact one of the commonest of our brown sea-weeds. It is found adhering to the rocks below low tide mark, and like the Laminariæ in general, has a large stalked thallus resembling a huge leaf. It is attached to the substratum by means of branched root-like hold fasts developed from the base of the stalk. The leaf-like expansion of the thallus in the case of *Ecklonia* is further marked by spinose projections and undulating edge. It belongs to the same family, and is closely allied to the weeds, that are, or rather were, used by the kelp makers of North-west Europe (i.e., *Laminaria digitata* and *L. stenophylla*) and like them contains a high percentage of potassium salts and an appreciable quantity of iodine. This latter element is not found in *Ecklonia* to the same extent as in *L. digitata*

and *L. stenophylla*, but the quantity compares well with most of the other Laminariæ and is considerably greater than that found in the Fuci.

The following table taken from Thorpe[1] will give an idea of the average yield of iodine of the chief sea-weeds of North-west Europe:—

Dry Weeds.	Percentage Iodine.	Pounds Iodine per ton.
Laminaria digitata (stem)...	·4535	10·158
" " (frond)	·2946	6·599
" *stenophylla*	·4777	10 702
" *saccharina*	·2794	6·258
Fucus serratus	·0856	1·807
" *nodosus*	·0572	1·281
" *vesiculosus*	·0297	·665
Halidrys siliquosa	·2131	4·773
Edible Japanese Sea-weed...	·3171	7·102
Hymanthalia lorea	·0892	1·998
Rhodomenia palmata	·0712	1·594
Chorda filum	·1200	2·688
Zostera marina	·0457	1·023
D'Urvillea utilis	·0075	·179
Macrocystis pyrifera	·0308	·690

Air-dry weeds carefully burnt to a loose ash give about 20% ash, so that the theoretical yield of the above Laminariæ should be 30 – 50 lbs. per ton. On the manufacturing scale Thorpe estimates that 25 – 30 lbs. per ton should be obtained. As a matter of fact the average obtained by the kelpers was less than 12 lbs. per ton, because in the early days the weed was burnt solely for the sodium carbonate—for this the kelpers had been taught to burn at a high temperature; the quality of the sodium carbonate being thereby improved, but much of the potash and most of the iodine was lost by volatilization. When it no longer paid to prepare sodium carbonate by this method (owing to the removal of the duty from Barilla and the introduction of the Leblanc process)

[1] Dictionary of Applied Chemistry, Vol. II., p. 338.

kelp was then burnt for the sake of the potash and iodine, but the kelp makers still persisted in burning their weed to a hard slag, thereby losing most of the iodine.

The difference produced by burning to a slag and loose ash is shown by the following analyses[1] (a sample of Scotch kelp being employed for each method):—

	Slag.	Ash.
K_2SO_4	13·95	12·71
KCl	17·79	18·09
NaCl	14	6·80
Na_2CO_3	3·92	3·43
Na_2S	heavy trace	slight trace
$Na_2S_2O_3$	·75	·17
NaI	·76	1·48
NaCNS	heavy trace	slight trace
Soluble organic matter	nil	·42
Insoluble	44·80	49·75
Water	4·05	7·00
	100·02	99·85
Total potash	18·77	18·32
Iodine (pounds per ton)	14½	28
Carbon in insoluble part	nil	9·00

More efficient methods of extracting iodine from sea-weeds were later introduced by Stanford, *i.e.*, (1) distillation process, (2) leaching-out process, both of which had the further advantage of yielding valuable by-products. A detailed account of these however would be out of place here.

The comparative yield of the three processes may be of interest and is therefore quoted from Thorpe's Dictionary, the calculations in each case being based on 100 tons of air-dried Laminariæ:—

[1] Thorpe, *op. cit.*, Vol. II, 339.

Kelp process—Yield = 18 tons of kelp giving 9 tons of salts + 270 lbs. iodine—residue valueless.

Distillation process—Yield = 15 tons of salts + 600 lbs. iodine—residue = charcoal (36 tons), tar, ammonia, etc.

Leaching process—Yield = 20 tons salts + 600 lbs. iodine—residue = algin (20 tons) + algulose (15 tons).

In the present example (*Ecklonia*) the plant was carefully incinerated at a low temperature in a muffle, and there is good reason to believe that practically the whole of the iodine was retained. The percentage found (·89) works out to approximately 20 lbs. per ton, which is considerably below the yield of the Scotch Laminariæ quoted above.

In the present case the determination of iodine (in the presence of chlorine) was made by the method of Jannasch[1] which depends on the fact that in a dilute solution of two or three halogens, nitrous acid sets free iodine only. The iodine is driven over in a current of steam and absorbed in an ice-cooled mixture of caustic soda and hydrogen peroxide (free of hydrochloric) and subsequently determined gravimetrically as silver iodide in the usual way. The reactions taking place are as follows:—

$$(\alpha)\ 2\,I + 2\,NaOH = Na\,I + NaO\,I + H_2O$$
$$(\beta)\ NaO\,I + H_2O_2 = H_2O + O_2 + Na\,I.$$

The detailed analysis of *Ecklonia exasperata* was as follows:—

Sand	...	1·27 %
C	...	·48
SiO_2	...	1·17
H_2O	...	2·30
SO_3	...	14·98

[1] *Zeit. für Anorg. Chem.*, I., p. 144, and quoted by Treadwell, *Quant. Anal.*, p. 254.

S	...	3·61	
Fe_2O_3	...	·44	
FeO	...	2·30	
P_2O_5	...	·75	
CaO	...	5·50	
MgO	...	5·19	
Cl	...	15·62	
CO_2	...	8·22	
K_2O	...	24·59	
Na_2O	...	18·15	
Iodine	...	·89	
		105·46	105·46

$$\left.\begin{array}{lr} \text{Subtract O equivalent to Cl} & 3{\cdot}52 \\ \text{,, \quad ,, \quad S} & 1{\cdot}81 \\ \text{,, \quad ,, \quad I} & {\cdot}06 \end{array}\right\} = 5{\cdot}39$$

Total ... ... = 100·07

In connection with the above piece of work I beg to express my appreciation of the kindly interest shown and valuable suggestions made by Professor Liversidge, F.R.S.

PROBLEMS OF THE ARTESIAN WATER SUPPLY OF AUSTRALIA, WITH SPECIAL REFERENCE TO PROFESSOR GREGORY'S THEORY.

By E. F. PITTMAN, A.R.S.M., Government Geologist of New South Wales.

[With Plates VIII. - IX.]

[Clarke Memorial Lecture delivered before the Royal Society of N. S. Wales, October 31st, 1907.

IN certain localities, when bore-holes are put down in the earth's crust, considerable volumes of water rise above the surface like fountains, and form a more or less permanent supply. These are termed Artesian wells, after ARTESIUM, the Roman name of one of the provinces of France where the first Artesian bore was put down. In these cases the phenomenon is accompanied by certain geological conditions, and the rise of the water is due to well recognised laws.

The best treatise extant on the occurrence of Artesian water was published by Professor T. C. Chamberlin, of Chicago University, in 1885.[1] In this monograph he gives the following statement of the conditions necessary for Artesian wells:—

I. A pervious stratum to permit the entrance and the passage of the water.

II. A water-tight bed below to prevent the escape of the water downward.

III. A like impervious bed above to prevent escape upward, for the water, being under pressure from the fountain head, would otherwise find relief in that direction.

[1] Fifth Ann. Rept. U.S. Geol. Sur., 1885, pp. 125 - 173.

IV. An inclination of these beds, so that the edge at which the waters enter will be higher than the surface of the well.

V. A suitable exposure of the edge of the porous stratum, so that it may take in a sufficient supply of water.

VI. An adequate rainfall to furnish this supply.

VII. An absence of any escape for the water at a lower level than the surface of the well.

With regard to condition III, it may be observed that the Artesian basin of Perth, Western Australia, is believed to have no continuous impermeable covering, nevertheless the water rises well above the surface in bores. Attention was drawn to this fact by the writer in 1901, and it was suggested that where even porous sand rocks form the upper strata of a basin, they offer such resistance to the vertical ascent of the water that if a bore be put down to the water-bearing bed a flowing well may result from the sudden relieving of the pressure.[1]

In 1905 Mr. M. L. Fuller, an eminent American geologist also described the occurrence of Artesian water at Long Island, New York, in some gravel and sand beds which have no impervious covering. He stated that, according to Mr. A. C. Veatch, "the occurrence of flows depended upon slight differences in the degree of porosity of the sands, which, however, were in all cases pervious throughout."[2]

It appears, therefore, that an impermeable covering is not an absolutely necessary condition for an Artesian basin, although it is present in most large basins.

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[1] The Mineral Resources of New South Wales (E. F. Pittman) 1901, p. 458.

[2] Contributions to the Hydrology of Eastern United States, 1905, M. L. Fuller, U. S. Geol. Sur., Water Supply and Irrigation Paper, No. 145, pp. 40 – 41.

Professor C. S. Slichter, has suggested[1] that Chamberlin's condition VII should be amended to read "an absence of any *easy* escape for the water at a lower level than the surface of the well."

The necessity for some such amendment is apparent when it is remembered that some Artesian basins have leakage to the sea, while in others the porous water-bearing beds are intersected by valleys of denudation, thus providing an escape for the water at a level which is lower than the surface of the flowing wells. In these cases it is clear that the resistance which the porous beds offer to the lateral flow of the water is sufficient to preserve the necessary head.

With the slight amendments just referred to the conditions prescribed by Chamberlin in 1885 may be accepted as governing the occurrence of Artesian water.

In the great Australian Artesian basin which comprises considerable portions of the States of Queensland, New South Wales, and South Australia, the observations of local geologists have established the fact that the conditions just referred to prevail. There are the porous sandstones of the Triassic Coal Measures (and in places the overlying Blythesdale Braystones) outcropping at considerable altitudes in Queensland and New South Wales, on the flanks of the Main Dividing Range, and dipping westward under the central Australian plains: there are the underlying impervious rocks (granites, and altered palæozoic sediments) which form the floor of the basin: there are the overlying impervious strata which cover the porous sandstones to a depth of several thousand feet: and, lastly, there is an adequate rainfall, averaging about twenty-five inches per annum, in those districts where the porous beds are exposed

[1] Water Supply and Irrigation Papers No. 67, U. S. Geol. Survey, The Motions of Underground Waters, (Slichter) 1902, p. 82.

at the surface. No one has succeeded in disproving the existence of any of these conditions, and it may be stated that the only material detail in which the Australian differs from any other well known basin is in regard to its much greater dimensions. There has therefore been no hesitation in ascribing the ascent of the underground water in the Australian basin to hydrostatic, or more properly, hydraulic pressure.

Recently however, this conclusion has been severely criticised by Dr. J. W. Gregory, F.R.S., formerly Professor of Geology in the University of Melbourne, but now of the University of Glasgow. In consequence of his great reputation as a geologist and the distinguished position which he occupies, Professor Gregory's opinions are entitled to respect and consideration; nevertheless there is evidence that his views in regard to this matter are not based upon personal investigation. It is understood that the only part of the Australian Artesian water-bearing area examined by him was the desert country in the vicinity of Lake Eyre, in South Australia, and that he has never visited Queensland or that portion of New South Wales where the porous intake beds are visible at the surface. It follows therefore that he is not in a position to speak with authority upon the geology of this interesting problem, and as many of his statements appear to be in opposition to observed facts they can not be allowed to pass unchallenged.

Professor Gregory's first criticism of the views of Australian geologists was given in a lecture at Bendigo, (Victoria), in 1901.[1] He asserted that in the case of the Australian Artesian basin the hydrostatic head must be lost, owing to friction, long before the bores are reached: he contended that the real cause of the ascent of the water

[1] "Variation of ores in depth—the controlling factors," Australian Mining Standard, December 12th and 26th, 1901.

was local, and could be explained by reference to the action of geysers: that Artesian flow is, in most cases, due to the earth's internal heat, the water being given off from cooling igneous rocks: that the Artesian bore through the upper impermeable strata relieves the pressure on the heated water and that its expansive force and imprisoned gases compel it to rise to the surface.

In a paper read before the Royal Society of New South Wales in 1903,[1] Mr. Knibbs combated the views of Professor Gregory and showed that

"Hydrostatic head never disappears by friction": that "the rate of hydrostatic head depends upon the rate of flow, and is very small when the velocity is small," and that "the earth's internal heat is not the chief cause of the ascent of the water, as proved by the fact that the pressure is never relieved so far as to allow of ebullition."

In 1906 Professor Gregory published a very interesting book,[2] in which he states at considerable length his reasons for disagreeing with the conclusions of Australian geologists in regard to the great Artesian basin. He asserts that the water of our flowing wells is plutonic and not meteoric—that it has, in fact never previously appeared at the surface, and that its rise is due to the influence of *temperature* and *rock-pressure*.

It is not proposed to discuss here at any length the general question as to the probability of very large bodies of underground water being of plutonic origin, *i.e.*, of their having been given off by cooling deep-seated igneous rocks, Suffice it to say that the view adopted by most American geologists, viz. that "*All* underground waters have their

[1] The Hydraulic aspect of the Artesian problem, by G. H. Knibbs, F.R.A.S., this Journal, Vol. XXXVII., 1903, pp. XXIV. - XLIV.

[2] The Dead Heart of Australia by J. W. Gregory, F.R.S., D.Sc., London, John Murray, 1906.

origin in rainfall" has much to commend it. The material point to be argued here is as to whether the *artesian water supply of the Australian basin* has been derived from rainfall, and has been stored in the porous sandstones under hydrostatic or hydraulic pressure, or whether, as contended by Professor Gregory, it has been evolved from underground masses of igneous rocks, and is forced above the surface in bores by the influence of temperature and rock-pressure. The Professor refers to the "simplicity" of the former hypothesis as if it were something reproachful, but it is generally conceded that a simple explanation of a geological problem is to be preferred to one involving far-fetched or complicated reasoning.

It is proposed to deal first with the objections urged by Gregory against the hydrostatic pressure theory, and then to consider the theory which he propounds in lieu of it.

Loss of Head through Friction.—The objections are based upon both physical and chemical considerations, and the principal one is that, owing to the great distance (600 miles) which the water would have to travel underground between the intake-beds on the flanks of the Dividing Range and the bores at Lake Eyre, friction would cause the disappearance of the whole of the head.[1]

So far as is at present known the Australian artesian basin is the largest in the world, but there are some other well known basins of very respectable dimensions; for instance the Paris basin is about 100 miles wide,[2] while the water-bearing beds of the Dakota basin extend for about 350 miles.[3]

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[1] The Dead Heart of Australia, pp. 300 – 305.

[2] Prestwich, Quart. Journ. Geol. Soc., 1872, XXVIII., p. LIX.

[3] The Motions of Underground Waters, C. S. Slichter. Water Supply and Irrigation Papers, U. S. Geol. Sur. No. 67, p. 56.

The Hon. Dr. G. Otis Smith, Director of the United States Geological Survey, writes under date July 13, 1907:[1]

"The questions raised have been referred to Mr. M. L. Fuller, who has had charge of artesian water investigations in a considerable portion of the country for a number of years. His statements are as follows :—'The greatest distance which water is known to travel underground in the United States is in the St. Peter sandstone, the water entering the intake area in the southern part of the State of Wisconsin at an altitude of about 875 feet, and flowing at an altitude of 575 feet in Central Kentucky 450 miles to the south-east. In an open porous sandstone of this type the loss of head is very slight, amounting to only about ·67 feet per mile, and there is no reason to believe that the water might not penetrate and give flows at a distance of 1,000 miles or more if the porous beds were continuous.'"

In view therefore of the fact that water is known to travel underground in America for a distance of 450 miles, it is difficult to understand why the possibility of its flowing 600 miles in Australia, under analogous conditions, should be so emphatically denied.

Gregory is of opinion that in ascribing the rise of the water in our Australian wells to hydrostatic pressure Australian geologists have underrated the resistance to the flow of water through rocks due to friction,[2] and he considers that as the water has to percolate, not through open tubes, but through the very minute pores of rocks which are under the pressure of some thousands of feet of overlying material, friction would soon obliterate the whole of the head.

If this opinion were correct it would be impossible to accept the theory of hydrostatic pressure to account for flowing wells in any of the larger artesian basins of the

[1] Personal communication.
[2] The Dead Heart of Australia, p. 300.

world. But its incorrectness can be easily demonstrated by extracts from Professor Gregory's own book. He quotes[1] from Box's Hydraulics to show that a 1 inch pipe discharging a gallon of water per minute will lose, owing to friction, 700 feet of head in a distance of 100 miles, and he asserts that if the water were flowing through sand instead of a pipe it would lose very much more head. He had previously[2] referred to the Grenelle Bore, in the Paris basin, as an example of a flowing well in which the ascent of the water is ***really due to hydrostatic pressure.*** Now according to Prestwich[3] and D'Aubree[4] the width of the Paris basin, or, in other words the distance between the intake-beds at Champagne and the Grenelle Bore, is just about 100 miles. Therefore if the water flowed between those two places through a 1 inch pipe instead of through the Lower Greensands, there would be a loss of 700 feet of head in the distance, and (according to Gregory) as the water actually flows through sand, the loss of head should be very much more. But Prestwich states[5] that the difference in altitude between the Champagne Hills and the Grenelle Bore only averages about 261 feet: therefore the water at Grenelle should not rise within at least 439 feet of the surface, whereas it actually rises 120 feet above the surface, or would if it were allowed to rise in an open pipe. It appears also that the loss of head in this instance is only about 136 feet (instead of 700 feet) in 100 miles.

Rate of Flow of Underground Waters.—It is clear therefore that either the flowing bore at Grenelle is not caused by hydrostatic pressure, or that the loss of head in the case of water traversing porous rocks is nothing like 700 feet in 100 miles. Let us enquire into the latter statement.

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[1] *Ibid.*, p. 303. [2] *Ibid.*, p. 282.
[3] Prestwich, Quart. Journ. Geol. Soc., 1872, XXVIII., p. LIX.
[4] D'Aubree, Les Eaux Souterraines, Vol. I., 1887, p. 209.
[5] *Op. cit.*

Gregory argues that inasmuch as the loss of head in pipes increases, owing to friction, as the diameter of the pipes decreases, in porous rocks the loss of head rises to a maximum, because the interstitial spaces represent pipes of exceedingly small diameter. The answer to this is that the loss of head also increases approximately as the *square* of the velocity,[1] and that therefore velocity is a much greater factor in determining loss of head than is either the distance travelled or the diminution of the diameter of the tubes: and the head is therefore maintained in artesian basins owing to the extremely slow rate of flow of the water in the porous beds. Knibbs has shown[2] that in a uniform stratum the velocity diminishes, as the distance from the bore is increased, in the ratio $\frac{r}{R}$, where r is the radius of the bore and R the distance of the point considered: that is to say, putting v for the velocity at the bore of radius r, and V for that at the distance R from its centre, $V = \frac{vr}{R}$. Consequently if a 6 inch bore discharges with a velocity of $5\frac{1}{2}$ feet per second from a porous bed of uniform thickness, the velocity of the water in the porous bed at a distance of one mile from the bore would be $\frac{1}{320}$ inch per second, or $22\frac{1}{2}$ feet per day: if the distance be increased to five miles, the velocity of the water in the porous bed would be reduced to $4\frac{1}{2}$ feet per day. In short we may conceive that, in the first instance, the water in an artesian basin would, unless there were a natural outlet, be practically without motion: in this case the pressure would be hydrostatic; then the putting down of bores would induce a flow, with high velocity in their immediate vicinity, but decreasing gradually to an infinitesimal rate of movement as the distance from the bores increased. The pressure would thus become hydraulic.

[1] The Dead Heart of Australia, p. 302.
[2] G. H. Knibbs, The Hydraulic aspect of the Artesian problem. This Journal XXXVII., 1903. p. XXX.

It would appear therefore that Professor Gregory, having in view the great velocity of the water as it rushes from the bores, has much overestimated its rate of flow in the porous beds remote from the influence of the bores.

In connection with this question it is interesting to note that Professor Slichter has made a number of accurate determinations of the rate of movement of groundwaters in America.[1] He used for this purpose an ingenious apparatus designed by himself. Several test wells are bored at short distances apart along the approximate course of the flow. The up-stream well is charged with a strong electrolyte, such as sal ammoniac, and as the solution passes down stream with the moving ground-water it forms a good electrolytic conductor of electricity. Each of the down-stream wells contains an electrode consisting of a nickeled brass rod, and electrical connection is made between the casings of all the test wells. As the electrolyte solution moves in the direction of the down-stream well the electric current between it and the up-stream well gradually rises, mounting rapidly when the electrolyte begins to touch the down-stream well. When the electrolyte finally reaches and enters the down-stream well it forms a short circuit between the casing of the well and the electrode, causing an abrupt rise in the current, which is recorded by an amperometer. By using three down-stream wells instead of one, the direction of the flow, as well as its velocity can be determined.

The following are the results of 27 determinations made by Professor Slichter,[2] at Long Island, New York :—

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[1] C. S. Slichter, The Motions of Underground Waters, Water Supply and Irrigation Papers of the U. S. Geol. Sur., No. 67, 1902.

[2] Ibid., p. 69.

Number of Station.	Depth of Wells in Inches.	Velocity of ground-water in feet per day.	Number of Station.	Depth of Wells in Inches	Velocity of ground-water in feet per day.	Number of Station.	Depth of Wells in Inches.	Velocity of ground-water in feet per day.
1	22	5·5	7	20	2·6	15	42	1·53
2	22	2·	8	21·6	0	15x	62·5	6
2x	22	6·	8	21·6	3·1	16	16	0
3	22	2	10	28	2·6	16x	16	77·
4	22	2	11	22	0·	16x	16	11·6
5	22	6·4	12	27	1·07	17	20	10·6
5x	22	5·4	13	16	96·	18	62	1·
5Y	22	8	13	16	6·9	21	16·5	21·3
6	34	5	14	17	9·3	22	16	5·6?

The mean rate of flow of the 27 determinations was 11·05 feet per day. The same writer has made determinations, by the chlorine and other methods, of the rate of movement of the underflow beneath the channel of the Arkansas River, in Western Kansas.[1] He says,

"Six miles below Garden, at a level of 10 feet below the river bed, the velocity was found to be 2½ feet per day. The fall of the river is about 7 feet per mile. The material below the 10 feet level is coarser than that above, and the velocity is undoubtedly higher. Determinations of the rate of underflow in the narrows of the Hondo and San Gabriel Rivers, in Southern California, by the author's critical method, gave rates of 3½, 4, 5½, and 7 feet per day."

According to M. L. Fuller,[2] the loss of head in the water dercolating the St. Peter sandstone, in the States of Wisconsin and Kentucky, amounts to only ·67 feet per mile. If it be assumed that the same rate of loss prevails in the Triassic sandstones of the Australian artesian basin, and there is no apparent reason why it should not, the total loss of head between the Queensland hills and the bores around Lake Eyre would only amount to about 400 feet; there is therefore nothing remarkable in the ascent of the

[1] The Motions of Underground Waters, E. C. Slichter, 1902. Water Supply and Irrigation Papers U. S. Geol. Sur. No. 67.

[2] Personal communication already referred to.

water in those bores in view of the high altitudes at which the porous beds outcrop on the flanks of the Queensland hills.

In the light of what has already been said, it is evident that Professor Gregory's objections to the hydrostatic pressure theory, so far as they are based upon the distance which the water has to travel and the loss of head by friction, cannot be sustained.

Other objections which he urges refer to apparent anomalies in regard to the temperature and pressure of the artesian wells. It must be admitted that remarkable differences of temperature and pressure do occur, and that it is not easy to give an explanation which is capable of definite proof; nevertheless several possible explanations can be advanced, and it may be stated that the anomalies to which the Professor draws attention are not confined to the Australian basin, having been observed elsewhere.

Anomalies in Temperature.—Gregory states[1] that—
"the hottest water does not come from the deepest wells. The water of the Clifton and Tinaroo wells is of the temperature of 139°, whereas the deepest well of this series is at Wallon, and its water is only 124°, and the well at Moree, 2,792 feet deep, has a temperature of 115°. . . The average increase of temperature below the surface of the ground is generally taken as 1° F. for every fifty-three feet in depth. Some authors maintain that this rate is excessive, and that the rate of 1° F. for every eighty feet is the true average. But many of the flowing wells in Australia show the rate of 1° F. for every twenty-two feet. This high temperature indicates that the water has probably come from a much greater depth than that of the water-bearing layer. It is, therefore, more likely to be plutonic than meteoric."

It may be remarked that observations in regard to the rate of increase of temperature with depth. owing to the

[1] The Dead Heart of Australia, pp. 315 – 317.

internal heat of the earth, have not shown very consistent results in other parts of the world, as will be seen by the accompanying table:—

OBSERVED TEMPERATURES IN EXCAVATIONS.

Locality.	Depth in feet of Excavation.	Depth in feet for increase of 1° F.
Bootle Waterworks (Liverpool)	1392	130
Przibram Mines (Bohemia)	1900	126
St. Gothard Tunnel	5578	82
Mont Cenis Tunnel	5280	79
East Manchester Coal Field	2790	77
Paris Artesian Wells...	1312	56·7
London Artesian Wells (Kentish Town) ...	1100	55
Yakoutsk frozen ground (Siberia)	540	52
Sperenberg Bore (Berlin)	3492	51·5
St. Petersburg Well (Russia)	656	44
Carrickfergus, shaft of salt mine	770	43
" " "	570	40
Slitt Mine, Weardale, Northumberland ...	660	34
Fort Randall Artesian Bore, Dakota, U.S.A.	576	17·5

In view of the extremely wide differences in the temperature gradient, as shown by these figures, it would surely be very illogical to contend that, because some Australian artesian bores give higher rates of increase than the *average* of those results quoted above, the water must be plutonic and not meteoric.

In the Dakota artesian basin the temperatures of the waters from flowing wells show even more remarkable anomalies than those in Australia. Darton[1] mentions that at the Fort Randall well, in the Missouri Valley, the rate of increase of temperature is 1° for each $17\frac{1}{2}$ feet, while at the Chamberlin well the rate is 1° for each $21\frac{1}{2}$ feet, and at the Pierre well 1° for each $24\frac{1}{2}$ feet. In other parts of the basin the rate varies down to 1° for each 41 feet. Darton also draws attention to the fact that the area

[1] Geothermal Data from deep artesian wells in the Dakotas, N. H. Darton, Quart. Journ. Sci, Vol. v., 1898, pp. 161 – 168.

within which the higher temperatures are met with corresponds with a deep valley in the submerged "bed-rock surface," while the area which is characterised by cooler conditions is coincident with an underground ridge of quartzite, which, in fact, outcrops at the surface in places. There are indications at the north side of the buried ridge that the quartzite is underlain by granite.[1]

It seems possible that these variations in the temperature gradient may be due to the irregularities in the submerged bed-rock surface, and to the differences between the conductivities and thermal capacities of the bed-rock and of the overlying water-bearing series respectively, though it is noteworthy that the author of the paper quoted considers that all the explanations which have yet been suggested, including that of "different ratios of conductivity" are unsatisfactory.

The abnormally high temperatures referred to by Gregory as occurring in some of the Australian bores may also be possibly due to the bores having been put down in proximity, in some cases, to centres of expiring volcanic activity. The Triassic rocks along the coast of New South Wales were intruded, during Tertiary times, by many dolerite dykes, and there is evidence all over the eastern States that volcanic activity was very wide-spread during that period. It is therefore only reasonable to suppose that the porous Triassic sandstones which form the base of the artesian basin have also been intersected by many dolerite dykes which do not appear at the present surface because they are older than the Post-Tertiary deposits of which it is formed. As a matter of fact specimens of dolerite have been brought up with the drillings from some of the bores.

It is admitted that it is difficult to find a perfectly satisfactory explanation of these differences in temperature,

[1] N. H. Darton, 17th Ann. Rept. U.S. Geol. Sur., 1895-6, Pt. II., p. 673.

and this is hardly to be wondered at, seeing that the great depths of the bores prevent us from ascertaining the exact conditions which prevail at their extremities. It may be as well to repeat therefore that the foregoing suggestions are merely put forward as *possible* explanations. In any case it is difficult to see that these anomalous temperatures are any proof of the truth of Professor Gregory's contention viz., that the water is of plutonic origin; for if it were we would expect it to reach the surface with a temperature of at least 212°, whereas in no single instance does it do so. The highest temperature recorded for any artesian well in Australia is 202° at Elderslie Bore, 4523 feet deep, and situated about 40 miles west of Winton in Queensland.

Anomalies in Pressure.—In considering anomalies in regard to the observed pressure of Australian artesian bore waters, Professor Gregory makes a critical analysis of the data published by the officials of Queensland, New South Wales, and South Australia. As a result, he considers that the irregularities in regard to the distribution of water pressure are too great to be explained by variations in the texture and thickness of the porous water-bearing beds, and he advances this as a further argument against the acceptance of the hydrostatic pressure theory. It is not considered that any useful purpose would be served by closely following the details of Gregory's criticism so far as it relates to the location of isopotential lines. It may be stated at once that the work done in determining the position of isopotentials, independently, in the three States, is patchy and very incomplete, and to deduce anything definite from it in its present stage would be like attempting to fit together a toy puzzle of which half the pieces are missing. Moreover it is quite possible that errors may have occurred in some of the determinations which would account for the apparent crossing of some of the isopotential

lines referred to by Gregory. It is very much to the credit of the hydraulic engineers of the three States that they have accomplished so much in the face of great difficulties, but Mr. J. B. Henderson informs me that most of the levels of the Queensland bores have been taken by aneroid observation, and although Mr. J. A. Griffiths (Mr. Henderson's assistant) performed this work with the greatest care, it is impossible that the same accuracy could have been obtained as if the dumpy level had been employed. Until, therefore, the work has been checked, and carried much nearer to completion, it would be futile to attempt to explain the inconsistencies which appear to exist in the published maps. It may be stated that similar anomalies in regard to pressure have been noticed in the artesian wells of the Dakota basin, and they have not been definitely accounted for, though several possible explanations have been advanced.[1]

It is understood that the isopotential work in South Australia has been performed with the aid of the spirit level, as has that in New South Wales, and the fact (recorded by Professor Gregory)[2] that Mr. J. W. Jones successfully predicted the height to which the water would rise in some localities, appears to be incapable of explanation except on the assumption that the flowing wells are caused by hydraulic pressure.

One statement of Professor Gregory's in regard to the subject of isopotentials requires to be amended. He says[3] that in New South Wales there is no evidence of regular decrease of pressure towards the west; but a glance at the map published by Mr. Allan[4] will show that the hydraulic

[1] Preliminary Report on Artesian Waters of a Portion of the Dakotas, N. H. Darton, Seventeenth Ann. Rept. U.S. Geol. Sur., 1895-6, pp. 668-9.

[2] Dead Heart of Australia, p. 293. [3] *Ibid.*, p. 311.

[4] The Drought Antidote for the North-west, New South Wales, Percy Allan, 1906, pp. 44. 45.

grade has a fairly uniform fall to the west and north-west. It may be added that the discrepancies noticed in the pressures of the adjacent wells may be due to their deriving their water from different porous beds. In connection with this question Mr. Allan[1] writes :—

"It must however be remembered that whilst in the case of Government bores the records have been well kept and the different flows determined until bed-rock has been obtained, yet in the case of private bores such data are not available, and there is the consequent possibility of the recorded pressure in a private bore being for a flow in a much higher sheet of water-bearing strata than that noted in connection with an adjacent bore. This necessitates the isopotential lines being taken as tentative."

Salinity of Artesian Waters.—Amongst Professor J. W. Gregory's objections to the theory of hydrostatic pressure, as applied to the Australian artesian basin, some of those upon which he lays most stress are based upon the chemical composition of the water. He states (1) that the water does not increase in salinity with sufficient regularity as it flows from east to west, or in other words from its source to the most distant wells; (2) that the dissolved constituents vary irregularly in nature as well as in amount in the wells of the central basin; (3) that the presence of the carbonates of soda and potash in the majority of the well waters, of lithium carbonate in the Helidon wells, and of zinc in "the well of Toowoomba" are evidence in favour of the plutonic origin of the water.

With regard to objections (1) and (2) it is surprising that any geologist should expect that a stratified deposit could extend for a distance of 600 miles, or more, without showing marked variations in what may be termed its accidental constituents, or that the salinity of water which percolates through it for that distance should increase regularly, from

[1] *Ibid.*, p. 45.

the intake to the farthest wells, by a sort of arithmetical progression. It is well known amongst the pastoralists of the Western Plains that shallow wells, which yield fresh water, are commonly found in proximity to others which yield salt water, and there is no indication on the surface as to the character of the water which may be met with at any spot. There is therefore nothing remarkable in the fact that the deeper (artesian) wells contain water of variable salinity, both as regards quality and quantity. On the contrary it is considered that the increase of salinity from east to west (as illustrated by the table on page 314 of *The Dead Heart of Australia*), is quite as marked as could be expected, and, as will be shown later, the *average* salinity of the South Australian wells is distinctly higher than that of the wells in the eastern States.

Professor Gregory refers to the Maria Creek bore, to the east of the basin, as being one of the richest in solid constituents,[1] but here he falls into an error through want of personal knowledge of localities. The Maria Creek bore (Queensland) is entirely outside of the artesian basin; in fact it is at least 65 miles to the eastward of the nearest outcrop of the intake beds. It is in an area of Permo-Carboniferous rocks, and was put down in search of coal. The chemical composition of its water has therefore no bearing upon the subject under consideration. Reference is also made to the excessive salinity (1,250 grains of solids per gallon) of the Boort well near Cunnamulla; but this is a shallow well which was put down in the shales and limestones of the Rolling Downs formation, and it is therefore several thousand feet above the porous sandstones of the artesian basin.

Alkaline Carbonates.—It is difficult to understand why the hydrostatic pressure theory should be condemned on

[1] Dead Heart of Australia, p. 312.

account of the presence of alkaline carbonates in the water, and it cannot be admitted for one moment that the presence of those substances is any proof of plutonic origin. In the first place there is nothing unusual in artesian water containing alkaline carbonates. Thus, some of the artesian well waters of Iowa contain these salts.[1] The artesian waters of Texas contain much alkaline carbonates; the average solid contents of these waters from six localities, from Fort Worth southwards, are given as follow:—[2]

Chlorides	(chiefly Na)	12,707	grains	per gallon
Carbonates	,,	20,750	,,	,,
Sulphates	,,	21,464	,,	,,
		54,921		

These water-bearing beds, the "Trinity Sands," are at the base of the Lower Cretaceous system. The artesian waters of the Cretaceous basin of Alabama also contain considerable quantities of alkaline carbonates.[3]

But in any case it is unnecessary to go to any plutonic depths to discover the source of the alkaline carbonates in the Australian basin, for it will be revealed by a slight examination of the porous beds where they outcrop at the surface. The Triassic sandstones have all the appearance of having been derived from the disintegration of granites. They consist of grains of quartz with a very felspathic looking cementing material. It is a fair assumption that the granites contained soda- and potash-felspars, the decomposition of which would yield just such a clay, and, as a matter of fact, analyses recently made in the Geological Survey laboratory of two samples of the porous sandstone

[1] Iowa Geological Survey, Vol. vi., 1897.

[2] Twenty-first Ann. Rept. U. S. Geol. Sur. Part vii., 1899-1900, p. 448.

[3] The Underground Water Resources of Alabama, E. A. Smith, Geol. Sur. of Alabama, 1907, pp. 361-362.

proved that this rock contains an appreciable proportion of alkalies. The results were as follow:—

Sample from near Dubbo, N.S. Wales ...	Potash	1·34%
	Soda	0·55%
Sample from near Texas on the Queensland-New South Wales Boundary	Potash	2·06%
	Soda	0·45%

The two localities are about 300 miles apart.

The soda and potash in the artesian water are thus easily accounted for, while the rain which falls upon the catchment area doubtless contains the usual proportion of carbonic acid, and an additional source would be provided by the oxidation of organic matter.

Lithium Carbonate.—With regard to the alleged presence of lithium carbonate in the Helidon wells it may be observed that these wells are outside the artesian basin, as the sketch-section (*Plate* VIII.) will show, and therefore the occurrence in them of lithium or any other substance would have no significance so far as the subject under discussion is concerned. As a matter of fact, however, Mr. Henderson the Queensland Government Analyst, informs me that he has examined three samples of Helidon water for lithium and has failed to find a trace of it even with the aid of the spectroscope.

Zinc in Toowoomba Water?—The reputed presence of 2½ grains of zinc per gallon in "the well of Toowoomba" can also be shown to be a matter of no consequence, so far as the origin of the artesian water is concerned. The town of Toowoomba is built, at an altitude of about 2,000 feet, upon a flow of basalt which forms the surface of the well known Darling Downs. The basalt overlies the Triassic sandstones, which dip to the westward, and which here constitute the intake beds of the artesian basin. The basalt is very vesicular in character, and is found to contain a plentiful supply of water, which is doubtless derived from rainfall. As a consequence of this a great number of wells

have been sunk in the neighbourhood of Toowoomba and over the Downs generally, the average depth at which the water is struck being about 100 feet from the surface. It will be understood then that this water-supply occurs at an altitude of nearly 2,000 feet above sea-level, and that it lies above the outcrop of the porous beds of the artesian basin. If zinc really occurred in this water, therefore, it could by no possibility have been derived from the artesian beds. But it is extremely doubtful whether there is any zinc in the Toowoomba well water in its natural state. Each of the wells is fitted with a pump which raises the water into a galvanised-iron tank alongside, and in most cases the pipe through which the water is conveyed to the tank is also constructed of galvanised iron. Mr. Henderson, the Government Analyst of Queensland, has forwarded me a communication from the Town Clerk of Toowoomba, enclosing extracts from a press copy of a letter, dated August 18th, 1897, forwarding a number of samples of water for analysis; referring to sample No. 3, from the Government Pound Paddock, (which is the one in which the zinc was found); the extract reads, "*This bore has a galvanised tube left in since completion six weeks ago, and has not been baled out since.*" The presence of zinc in the water can therefore bê easily understood.

Salinity of Artesian Water as compared with Mine Water.—While the *quality* of the saline constituents of the artesian water cannot be taken as proof of its plutonic origin, the *quantity* of salts in solution must assuredly be regarded as an argument strongly opposed to Professor Gregory's contention. It has already been stated that the porous water-bearing sandstones of the Triassic Coal Measures consist of quartz sand with a rather felspathic cementing material, and it is therefore to be expected that water percolating through these beds would not carry such

a high percentage of mineral salts in solution as if it had been in contact with slates, shales, or limestones. A comparison of the analyses of the artesian waters with those of mine waters fully bears out this conclusion, as the following figures will show. All the available analyses of waters from the porous beds of the artesian basin in Queensland, New South Wales, and South Australia have been taken for the purpose of this comparison.

WATERS FROM POROUS BEDS OF ARTESIAN BASIN.

143 samples from Queensland give an average salinity of 47·94 grains per gallon.

177 samples from New South Wales give an average salinity of 56·35 grains per gallon.

14 samples from South Australia give an average salinity of 141·62 grains per gallon.

The average salinity of the 334 samples from all three States is 56·32 grains per gallon.

All the available analyses of Australian *Mine Waters* have also been collated. There are 35 of these, viz. 2 from Victoria, 11 from New South Wales, and 22 from West Australia, and their average salinity is 1674·48 grains per gallon. These waters were all taken from comparatively shallow depths, and their high salinity, as compared with that of the artesian waters, is evidence of their having been in contact with more highly mineralised rocks. If now we consider the conditions under which *plutonic waters* would occur, having their source at great depths, and percolating, under extremely high temperature and pressure, through calcareous, ferruginous, and felspathic rocks, it is obvious that their salinity would be far in excess, not only of the artesian waters, but of the mine waters referred to above; it might, in fact, be expected to amount to many thousands of grains per gallon, for the waters, under such peculiar conditions of heat and pressure, would become supersaturated with salts.

In view of the foregoing considerations it is contended, that the chemical composition of the Australian artesian waters, so far from indicating a plutonic origin, constitutes very strong evidence against it, and is, furthermore, quite consistent with the assumption that they have been derived from rainfall.

It will also be noted that the average salinity of the South Australian waters is much higher than that of the waters from the eastern States, a fact which is in accordance with the supposition that the water travels from the Great Dividing Range westwards towards Lake Eyre.

Gas Pressure.—In dealing generally with the subject of flowing wells, Professor Gregory separates those whose waters are charged with gas from those which are not so characterised; and this is a distinction which no one is likely to cavil at, since the cause of their ascent is clearly different in the two cases. He makes the following statement however[1]—

> "Some of the flowing wells in the artesian area of New South Wales are classed by Mr. Pittman as 'Mineral waters.' Thus the water known as Zetz Spa, found in the Talbragar Valley, North-east of Dubbo, comes up through a bore hole; and there is no obvious reason why it should be placed in a different category from some of the artesian waters. It contains 224 grains of solids per gallon, including 183 grains of bi-carbonate of soda."

A reference to the work alluded to[2] will show that my reason for classing this as a mineral water was the very obvious one that it is heavily charged with carbonic acid gas. Moreover this bore, although situated within the extreme boundaries of the artesian basin, was put down in an inlier of Permo-Carboniferous rocks in search of coal.[3]

[1] Dead Heart of Australia, pp. 315-316.

[2] The Mineral Resources of N. S. Wales, E. F. Pittman, 1901, pp. 448-9.

[3] W. Anderson, Ann. Rept. Dept. Mines N.S. Wales, 1888, p. 184.

Singularly enough, in a subsequent paragraph of his book, (page 317) Professor Gregory states that the water from this well is "*charged with carbonic acid.*"

It has already been stated that the Helidon wells (Queensland), the waters of which are also charged with *carbonic acid gas*, are outside the artesian basin, and it is probable that they also penetrate Permo-Carboniferous rocks underneath the Triassic. The Maria Creek bore (Queensland), from which there were emissions of marsh gas, and from which the flow of water was intermittent and finally ceased, is undoubtedly in the Permo-Carboniferous rocks, and well outside the artesian basin. Another bore from which both marsh gas and petroleum were emitted is situated at Roma, in Queensland, and here again it seems probable that the gas and oil, which are not characteristic of the ordinary artesian wells, may emanate from underlying Permo-Carboniferous rocks penetrated by the bore. In a bore which was put down at Grafton (N.S. Wales) with the object of testing the Triassic sandstones of the Clarence River basin for water, only a small supply, which rose level with the mouth of the bore, was met with between 40 and 100 feet from the surface. The bore was continued to a total depth of 3,700 feet, and at 3,100 feet a considerable volume of marsh gas was given off, and burned at the mouth of the well. Marine beds of the Permo-Carboniferous system are known to occur at Drake, to the north-west of Grafton, and it seems probable that the fresh-water coal-bearing beds of that system also underlie the Clarence basin, and that the gas which was met with in the Grafton bore emanated from them.

With regard to the presence of sulphuretted hydrogen in artesian water, Mr. Hamlet, Government Analyst of N.S. Wales, stated (in a report to the Works Department, dated 30 January, 1901) that he had failed to detect gas at three

bores visited by him. The characteristic odour however is distinctly noticeable at most of the bores, and the occurrence of sulphuretted hydrogen is doubtless due to the reducing action of decomposing organic matter upon sulphates, the latter being probably derived from the oxidation of pyrites, which usually occurs in the vicinity of intrusive dykes.

Tidal Wells.—While no satisfactory explanation can as yet be offered to account for the rise and fall of the water in the Urisino Well (N.S. Wales), the suggestion made by Gregory,[1] that the phenomenon may be due to the escape of carbonic acid gas, cannot be endorsed. There is no visible evolution of gas, the surface of the water being apparently quiescent; moreover the writer stood for a considerable time on a staging which had been erected inside the mouth of the well, and the fact that the air there was perfectly innocuous is proof that there was no accumulation of carbon dioxide. The suggestion as to geyser action would appear to be equally untenable. It may be added, that the Professor is mistaken in supposing that more than one tidal well is known in New South Wales. The Ninety-one Mile is a Government bore, situated about six or seven miles from the Urisino bore, but it does not exhibit variations in the height of the water as the latter does. It is probable that the two names have been confused on account of the Urisino being so close to the Ninety-one Mile.

Oxton Downs Bore—Water in Granite?—The artesian bore at Oxton Downs (Queensland) is said to have obtained its supply from granite, and Professor Gregory regards this as *certain evidence that the water is plutonic.*[2] If it could be proved that this water was actually derived from granite the occurrence would be unique, for although very many

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[1] Dead Heart of Australia, p. 330.

[2] *Ibid.*, p. 317.

bores have bottomed in that rock, there is no other instance on record in which a flow was obtained after the granite was penetrated. For this reason it might have been expected that the statement as to the source of the Oxton Downs water would be received with very great caution, until it had been placed beyond all doubt, or at least until other similar occurrences had been met with. This bore is a private one, and was put down under the superintendence of Mr. Hugh Moor, at that time (January 1891) Manager of the Manfred Downs Station. The Queensland records show that the bore was not visited by a Government official until nearly six years after its completion. It was then inspected by Mr. J. A. Griffiths, who was in charge of the Hydraulic Survey of the Northern Division of Queensland, under Mr. J. B. Henderson, Hydraulic Engineer for the State. Mr. Griffiths' report, which is dated 30th November, 1896, states—

"A small flow was met with in the sandstone at 700 feet, a little more at 900 feet in the granite, and the main flow, estimated at 120,000 gallons per diem, issued from a fault or crack in the granite at 1,060 feet."

As Mr. Griffiths obtained this information from Mr. Hugh Moor, I wrote to that gentleman and asked him what evidence he had of the crack or fault. He has been courteous enough to send the following reply:—

"The only evidence I can give you as to the water being struck there in a fault is from the borer's description, which as far as I can remember was as follows. I know they had been drilling for some weeks on granite, making very slow progress, when all at once the drill dropped six or eight feet according to their report, at a depth, if I remember right, of about 1,020 feet. Water shortly began to increase in flow after this drop, and they went on a few feet more, I forget how many, in fairly soft drilling, and then came on hard again, when I knocked them off. During the time they were following this crack (as we called it) down, a

lot of flaky granite came up in the flow, very thin, mostly oval, and about as big as a three-penny piece. A lot of these drillings were saved at the time and were left on the Station when I left there. I think there is no doubt this was a crack or fault, but how wide or deep, or in what direction trending, I could not tell you. I am certain the top rock was granite, as I believe some of the drillings were submitted to yourself at the time, and you pronounced them 'bed-rock.'"

There does not appear to be very much evidence here upon which to base an assertion that the water is of plutonic origin. It is clear that the main water-bearing sandstone beds must be in proximity to the bottom of the bore, for some sandstone was penetrated and a small flow obtained from it. It seems highly probable therefore that the crack or fissure in the granite is in direct communication with a lower stratum of the porous beds, and that the water was really derived from the latter.

Outlet for Artesian Basin.—In connection with the supposed existence of an outlet for the subterranean waters at the Gulf of Carpentaria, Professor Gregory gives a section of the artesian basin from the gulf to Charleville, and he shows, as a marked feature of this section, a rock barrier or submerged range of granite in the vicinity of Manfred Downs. In speaking with reference to this he says[1]

"The section on page 306 shows that an outlet to the Gulf of Carpentaria is of no use to the deep basin beneath the Lake Eyre country, for its waters are far below the level of the outlet into that Gulf. Hence so far as concerns the flowing wells of the south-western part of the central artesian basin, the water must be stagnant."

It is difficult to understand why the Professor arrives at this conclusion. The water must circulate through the lowest parts of the basin, so long as it has sufficient head.

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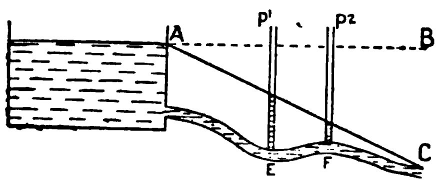
[1] *Ibid.*, p. 299.

The fact that "*that part of the basin beneath Lake Eyre is far below the level of the outlet into the Gulf of Carpentaria*" is of no consequence so long as the *source* of the water, or in other words the *outcrop of the porous beds*, is at a sufficient altitude above the submerged granite barrier at Manfred Downs. If Gregory had continued his section from Charleville on to Toowoomba, as has been done in the sketch (*Plate* VIII), the fact that the porous beds there have an outcrop at least 1,000 feet higher than Charleville would have been apparent. It may be added that the water beneath Lake Eyre is not stagnant for the same reason that the water at E, in figure 1, (which is reproduced from



"The Dead Heart of Australia") would not be stagnant, but would flow over the barrier at F, so long as its source is at a higher level.

An inspection of the country between Brisbane and Toowoomba would probably convince Professor Gregory that the artesian basin has no outlet in the neighbourhood of the first named place. It will be seen in the section (*Plate* VIII), that Toowoomba lies at an elevation of about 2,000 feet above sea-level, that the Triassic sandstones here have a *westerly* dip, and that immediately east of Toowoomba there is a steep escarpment leading down to the coastal plain on which Brisbane is situated. A considerable outcrop of palæozoic rocks (regarded by Dr. Jack as Lower Carboniferous) occurs near Brisbane, and it is more than possible that an area of Permo-Carboniferous sediments may underlie the Triassic sandstones near the mountains. A bore at Laidley, 51 miles west of Brisbane,

yielded a flow of 1,600 gallons per day of very saline water at a depth of 2,512 feet. Another bore at the Racecourse, four miles from Brisbane, reached a depth of 1,781 feet, and yielded 8,228 gallons per day. Both these flows are believed to be of local origin.

Darling River Rainfall and Run-off.—The late Mr. H. C. Russell, Government Astronomer of N. S. Wales, first drew attention to the fact that only a very small percentage (estimated by him at 1·46%) of the rainfall on the Darling catchment area actually flowed past Bourke through the channel of the river, whereas he assumed that in the case of the Murray the run-off of the river amounted to 25% of the rainfall. He concluded therefore, that a large proportion of the Darling rainfall must pass underground. Commenting on this, Professor Gregory says,[1]

"The view that the ascent of the water in the flowing wells is due to the pressure of water in the Queensland hills does not seem to me to be any longer tenable. The responsibility for this view rests with the meteorologists. It was originally based on a 75% under-estimate of the discharge of the Darling River, a 300% over-estimate of the discharge of the Murray, and a large exaggeration of the estimated proportion of the rain discharged by rivers in general."

He also makes the following statement,[2]

"The Murray River and the Darling both discharge about the same proportions of the water that falls upon their basins; and considering the climate and the nature of the country that they drain, the amount is not unduly low."

If these emphatic statements could be proved to be correct, it must be admitted that the evidence in favour of the meteoric origin of the artesian water would be seriously discounted, but indeed they are very far from being correct. Mr. Russell's original estimates of the run-off of

[1] *Ibid.*, p. 336. [2] *Ibid.*, p. 297.

the Darling and Murray rivers were necessarily based upon very imperfect data; since then however much more systematic gaugings of these rivers have been carried out by the engineers of the Public Works Department, and, consequently, it is now possible to obtain fairly accurate data.

Mr. R. T. McKay, Assistant Engineer of the Works Department, has dealt at considerable length with this question in a paper read before this Society.[1] The following tables have been copied from his paper:—

TABLE OF RAINFALL AND RUN-OFF OF THE DARLING RIVER AT WILCANNIA. Catchment area 235,000 square miles.

Year.	Annual discharge of the Darling at Wilcannia in millions of cubic feet.	Mean discharge in cusecs.	Second feet per square mile.	Mean rainfall in inches over catchment.	Run-off in inches over catchment.	Percentage discharged.
1894	253,644	8,043	0·034	26·81	0·464	1·73
1895	60,234	1,910	0·008	19·53	0·110	0·56
1896	87,733	2,782	0·012	21·14	0·161	0·76
1897	70,199	2,226	0·009	18·94	0·128	0·67
1898	57,049	1,809	0·008	15·87	0·104	0·66
1899	27,783	881	0·004	16·04	0·051	0·31
1900	69,474	2,203	0·009	16·33	0·127	0·77
1901	32,167	1,020	0·004	15·71	0·059	0·37
1902	710	22	0·0001	11·22	0·001	0·01

TABLE SHOWING RAINFALL AND RUN-OFF OF MURRAY RIVER AT MORGAN. Catchment area 408,000 square miles.

Year.	Annual discharge in millions of cubic feet.	Annual discharge in acre feet.	Mean annual discharge in second feet.	Run-off. In second feet per sq. mile.	Run-off. In inches over catchment	Rainfall in inches over catchment	Percentage discharged
1895	509,951	11,706,945	16,170	0·039	0·54	17·35	3·12
1896	297,939	6,839,786	9.448	0·023	0·32	18·21	1·75
1897	277,548	6,371,669	8,801	0·022	0·29	16·46	1·76
1898	281,787	6,468,984	8,935	0·022	0·30	15·28	1·96
1899	274,619	6,304,428	8,708	0·021	0·29	15·23	1·90
1990	424,271	9.739,989	13,454	0·033	0·45	16·64	2·70
1991	242,321	5,562,963	7,684	0·019	0·26	14·68	1·77
1992	93,274	2,141,291	2,958	0·007	0·10	10·64	0·94
Means	300,214	6,892,007	9,519	0·023	0·32	15·56	2·00

[1] Rainfall and discharge of the Murray River and its tributaries, R. T. McKay, this Journal, 1906, Vol. XL., pp. XLVI – LXXXII.

—Aug. 7, 1907.

Taking the mean of the figures in the last columns of the two tables, it will be found that the percentage ratio of the run-off to rainfall of the Murray, at Morgan, is about three times as great as that of the Darling at Wilcannia. But this comparison is unsatisfactory, because, Morgan being below the junction of the Darling with the Murray, the result obtained there will include the run-off of the Darling; and again, Wilcannia being about 230 miles above the junction, the percentage of run-off there is higher than it would be at Wentworth, because the Darling receives no tributaries between the two towns, and this stretch of the river is subject to great loss from evaporation. I therefore asked Mr. McKay whether he could give a more exact comparison between the two rivers. In reply he says[1]:—

"In accordance with your request, I have continued the investigations of rainfall and run-off of the Murray River and its tributaries, and am now able to make a comparison of the Murray and Darling catchments at the junction of the two rivers. It has been asserted that the percentage of run-off of the Darling is about equal to that of the Murray, but such a statement must have been made without a knowledge of the various watersheds.

"Dealing with the period 1895-1903 inclusive, of the Darling catchment at Wentworth, and the Murray catchment at Wentworth, the following results are obtained :—

1895	Murray	percentage	of run-off is	19	times	greater than	Darling
1896	"	"	"	7	"	"	"
1897	"	"	"	9	"	"	"
1898	"	"	"	9	"	"	"
1899	"	"	"	21	"	"	"
1900	"	"	"	11	"	"	"
1901	"	"	"	17	"	"	"
1902	"	"	"	180	"	"	"
1903	"	"	"	4	"	"	"

"Taking each catchment as a whole, it will be seen for the nine years in question, that every square mile of Murray watershed

[1] Personal communication dated 29th August, 1907.

discharged 31 times more rainfall than a similar area of Darling watershed. In the above the abnormal drought year 1902 is included, and perhaps it might be regarded as unfair to include such a year in comparative records of run-off. If 1902 be excluded for the period under review, we find that the proportion of rainfall discharged from the Murray catchment is 12 times greater than that of the Darling. The volume discharged by each river must not be confused with the percentage of run-off, as the Murray at Wentworth does not discharge anything like 12 times the volume sent down the Darling channel. This, of course, is obvious, as the Murray watershed is so much smaller than the Darling.

"The information on which the above calculations are based, is as complete and reliable as it is possible to attain with the available data of river discharges and rainfall observation and may be accepted as within the reasonable limits of accuracy."

It is evident from Mr. McKay's very interesting results, that, although the late Mr. Russell's figures were based upon very imperfect data, they were not, after all, for purposes of comparison, so very far from the truth.

It may therefore be regarded as a fact that the ratio of run-off to rainfall in the case of the Murray is very much higher than it is in the case of the Darling, and this is undoubtedly due to marked differences in the geology of the two catchment areas. The tributaries of the Murray (above Wentworth) all flow over granitic rocks, or dense palæozoic sediments; on the other hand, all the tributaries of the Darling, in their upper reaches, cross the porous intake beds of the artesian basin, and thus a large proportion of the rainfall finds its way underground, and feeds the flowing wells. These tributaries of the Darling are the Bogan, Macquarie, Castlereagh, Namoi, Gwydir, McIntyre, Dumaresq, Culgoa, and Warrego.

Evaporation.—Professor Gregory discusses at considerable length the question of evaporation, and endeavours

to show that most of the Darling rainfall is lost in that way rather than by percolation underground. He states[1] that evaporation would get rid of more rain than ever falls in Central Australia. No one would think of questioning the truth of this statement, but it has little or no bearing upon the subject under discussion. The water does not enter the porous beds in *Central Australia*, but on the flanks of the Dividing Range, at high altitudes, where the rainfall is much greater, and the evaporation much less than it is in the central plains.

Internal Heat of the Earth.—The objections to the hydrostatic pressure theory having been discussed and answered, Professor Gregory's suggestions as to the cause of the ascent of the water in the flowing wells may now be briefly considered. They are that it is due to the internal heat of the earth, and to the effects of rock pressure. With regard to the first it may be stated that if the earth's internal heat were sufficient to cause the water to rise above the surface in bores, it would, before the bores were put down, have forced it back along the porous beds, with the result that it would have overflowed at the surface; in other words, the porous beds would never have become saturated with water. Another objection is that the water is not hot enough to be accounted for in this way, the hottest water flowing from an artesian bore being 10° below boiling point.

Rock Pressure.—The second suggestion is that the water is forced to the surface by the pressure of an overlying sheet of impermeable rock. On this subject Gregory writes[2]:

"Attention was first called to the importance of rock pressure in reference to flowing wells by R. Hay. . . . See *e.g.* F. B. Gipps, Journ. R. Geogr. Soc. Austral. (New South Wales Branch), Vol. VI., 1896, p. 4."

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[1] Dead Heart of Australia, p. 325. [2] *Ibid.*, p. 289.

Several objections to the theory that flowing wells are due to rock pressure suggest themselves. In the first place the effective pressure at any given point in the porous beds will be less than that due to the total weight of the overlying rocks, because on account of the cohesion of these rocks, and the continuity or lateral extension of the beds, they act more or less like the arch or girder of a bridge. The weight of the overburden at any point would not be completely felt until a depth had been reached where the rocks were in a plastic state.

If a single brick be knocked out of the lowest course of a high wall, the weight of the wall will not close up the space left by the brick, because of the cohesion between the bricks and mortar, and because, in the different courses, the bricks are laid "breaking joint." If the bricks were laid accurately and vertically over one another, and without any mortar, the space caused by the withdrawal of one would be immediately filled by the fall of all the overlying bricks.

Then again, if the pressure on a porous bed be sufficient to squeeze out the water when the bed is intersected by a bore, it is evident that the same pressure would have been sufficient to prevent the water from filling the porous bed in the first instance.

A third argument against the rock pressure theory is that even if it were possible for a porous bed to be first filled with water, and subsequently subjected to the rock pressure suggested by Professor Gregory, the effect would be that the water would return to the surface along the intake area; for the pressure, being vertically downwards, would have a tendency to squeeze the water laterally along the porous bed until it escaped at the surface. The ultimate result of the pressure on the porous bed would be to render it dense and indurated, and it would thus lose its capacity for absorbing water.

The theory of rock pressure as a cause of flowing wells was advanced many years before it received the advocacy of Mr. Robert Hay. It has been ably dealt with by Mr. W. H. Norton, an American geologist of high repute, from whose writings[1] the following extract may be quoted:—

"A rival theory to the hydrostatic theory was that of 'rock-pressure,' which assumed that the water of artesian wells is squeezed out of the aquifer by the enormous pressure of the superincumbent rocks. This was answered by Arago early in the 19th century, but lingering in the popular mind, and again put forward of late years as an explanation of the flows of petroleum and natural gas, it has once more been laid by Leslie (Ann. Rept. Penna. Geol. Sur., 1885), and by Orton (Geol. Sur. Ohio. Econ., vol VI.). Recently it has been revived, as at least a subordinate and occasional factor in artesian flows, by Professor Robert Hay.

"Assuming a specific gravity of three times that of water for the strata of a region to the depth of 600 feet, he states that at that depth the pressure of the superincumbent rocks amounts to fifty-two atmospheres, and that if a water-bearing stratum at that depth be pierced by the drill, we should then have the rock pressure of fifty-two atmospheres squeezing the water out of the rock pores, and granting sufficient plasticity in the rock, and a sufficient quantity of water, it must rise in the tube, which has only the pressure of one atmosphere upon it. A large bore to the well, and a small supply of water, would be against it reaching the surface. On the other hand, a bed-rock with mobile molecules at or near saturation under this enormous pressure must cause, in a narrow tube a flowing well.

"No objection need be offered to the supposition that circumstances might occur in which, for a short time, rock pressure might produce a flow of water under certain assumed conditions. But such occurrences must be local and temporary, as is the flow from wells sometimes produced by earthquake shocks.

[1] Artesian Wells of Iowa, W. H. Norton. Iowa Geol. Sur., Vol. VI., 1897, pp. 132, 133.

"Flow from rock pressure demands as its first condition that the rock of the water-bearing stratum has lost its cohesion. It must be plastic and mobile, crushed and comminuted ; otherwise it exerts no more pressure on the water in its interstices than do the iron walls of a water-main on the water flowing within them. The walls of a high building exert great pressure on their foundations, but it would hardly be suggested that this 'rock pressure' exerted upon the water pipes passing through or beneath these foundations, is the cause of the rise of water from them to the upper stories of the building. And not only must the rock of the water-bearing stratum be crushed aud incoherent in order to transmit rock pressure to the water which it contains; that water must also have entered the stratum before the pressure was exerted upon the rock, or before the rock was in a condition of mobility so that it could transmit the pressure to the water. For a pressure sufficient to squeeze water out of a stratum is sufficient to prevent the entrance of water into that stratum. A flow from rock pressure is limited, therefore, to the amount of water which the water-bearing stratum will hold without replenishing.

"With the theory of rock pressure as a general cause of artesian flows, Arago's summary dealing is still sufficient (Sur les Puits Fores. Annuaire par le Bureau des Longitudes, pp. 228 – 229, Paris, 1835). He showed that there are three cases of rock pressure which may be considered. The rocks above, and including the upper impermeable stratum, either continue to yield until they come in contact with the lower impermeable stratum, or they stop in a position of equilibrium before that contact, or they experience an oscillatory movement. In the latter case the flow will be intermittent, and in the first two cases it will stop entirely, and thus in any case the theory is incompetent to account for the steady flow of artesian wells."

With the object of ascertaining whether Mr. Robert Hay's explanation (quoted by Professor Gregory) as to the cause of the Kansas flowing wells, had received official endorsement in the United States, I wrote to the Hon. Dr.

Geo. Otis Smith, who courteously replied as follows, on the authority of Mr. M. L. Fuller :—

"Rock pressure as a cause of artesian flows has been advocated by several geologists besides Mr. Robert Hay, but has never been supported by any real evidence, and has never received official sanction, nor has it been generally accepted by careful private investigators. In fact, it should be regarded simply as a suggestion advanced to explain flows for which no other cause was known at the time.

"While no special investigations have been made of the Kansas wells, which you mention, they appear to differ in no way from many others developed in this country in the last few years. Flows from rocks which do not outcrop at the surface, and which are devoid of the usual basin structure, are not at all uncommon. In most instances the water reaches the lower water-bearing beds through vertical joints (or faults), the head of the water being determined by the ground water level at the point where the joints reach the surface. This is probably the case in the Kansas locality."

With regard to Professor Gregory's reference to a second (and Australian) advocate for the rock pressure theory, viz., Mr. F. B. Gipps, it may be stated that Mr. Gipps' views on this subject have not received the support of scientific men in Australia, but on the contrary have been severely criticised.[1]

In regard to the present reckless waste of the artesian water, and the question as to what extent the bores may be increased without overtaking the supply, Professor Gregory sounds a warning note which will appeal to most thinking men. The Australian artesian basin is the largest in the world, but there can be no doubt that even it must have its limits of productiveness. In the United States, artesian basins have been exhausted to such an extent that

[1] This Journal, Vol. xxvii., 1893, pp. 431 - 443.

the water ceased to rise above the surface. A notable instance is that of the basin from which the city of Denver draws its water supply. It was discovered in 1884 and within a few years about 400 wells had been drilled, principally within the city; by the end of 1890 all but six of the city wells had to be pumped.

Professor Slichter, in commenting upon the fact, states that it is probably due to the low porosity and transmission power of the water bearing strata, rather than to the lack of rainfall upon the catchment area, and that the water withdrawn represents a supply stored in the rocks but not readily transported by the strata to meet the enormous draft. He adds—

"It must be kept well in mind, that there is a limit to the amount of water that can be withdrawn from an artesian basin. There is no such thing as an inexhaustible supply in this connection. The amount of water available is limited on the one hand by the amount of rainfall upon the catchment area, and the facility with which the rainfall can obtain entrance to the porous stratum, and on the other hand by the capacity of the water-bearing rock to transmit the water over long distances, and diminution through leakage and seepage. These two limiting conditions are usually of sufficient magnitude to render the overdrawing of the supply a practical and present danger which should be constantly kept in mind."[1]

In Queensland and New South Wales increasing numbers of bores are giving diminished flows, and in some, for instance the shallow bores on Killara Station in the Bourke district, the water has ceased to rise above the surface. In nearly all these cases the bores are situated near the margin of the basin, where one would expect the first sign of depletion to manifest itself. It is unfortunate that accurate records were not kept, from the first, of pressure

[1] The Motions of Underground Waters, C. S. Slichter, 1902. Water Supply and Irrigation Papers U,S. Geol., Sur., No. 67, p. 94.

and flow at all the bores, but in New South Wales, at any rate, this work is now being thoroughly carried out under the superintendence of Mr. L. A. B. Wade, Chief Engineer for Water Supply etc. Isopotential lines are being systematically charted, the intake beds are being surveyed, and, when this is done, it is intended to take continuous gaugings of large streams where they enter and where they leave the porous rocks, with the object of determining the amount of water lost by percolation.

It may be confidently reaffirmed that the great Australian water-bearing basin is a true artesian area, that the water of the flowing wells had a meteoric and not a plutonic origin, and that hydraulic pressure is the chief cause of its ascent.

In conclusion, I venture to think that Professor Gregory's choice of a metaphor, in the title which he has given his book, is not altogether a happy one. When the heart ceases to beat, decay of all the other members of the body speedily follows. But if the heart of Australia, as symbolised by the desert country around Lake Eyre, be really dead, as suggested by the distinguished author, it is some consolation to know that there is still a fair amount of vitality in the head and limbs of our national body, as represented by the more fertile districts nearer to the coastline.

POSTSCRIPT.

The rocks termed *Triassic* in this paper include the lower water-bearing sandstone (of fresh-water origin) of the great Australian artesian basin. In Queensland they are known as the *Trias-Jura*, and are there overlain in places by the *Blythesdale Braystone*, a porous marine sandstone, which forms the basal bed of the Lower Cretaceous system. The *Blythesdale Braystone* was probably a littoral deposit along the eastern margin of the Cretaceous sea, and it may not extend very far in the direction of its dip. It is not

known to occur in the State of New South Wales, where the artesian water most certainly occurs in the older *Triassic* (or *Trias-Jura*) sandstones.

The *Trias-Jura* rocks of Queensland are characterised by the presence of the fossil plants *Tæniopteris Daintreei* and *Thinnfeldia*, and these fossils have also been recognised in New South Wales, both in the great artesian basin and in the Clarence River basin. In the Hawkesbury (Triassic) Sandstones of New South Wales, which are lithologically indistinguishable from the last named, *Tæniopteris Daintreei* has not, so far, been met with, although *Thinnfeldia* is plentiful. It is not quite certain therefore, at present, whether the Hawkesbury Sandstones of New South Wales are identical with the Trias-Jura Sandstones of Queensland, or whether they occupy a lower geological horizon than the latter. About 20 miles north of Gulgong (New South Wales) there is a fresh water (lacustrine) deposit containing numerous fish remains together with *Tæniopteris Daintreei* and other plants.[1] This deposit occupies a denuded hollow in the Hawkesbury Sandstone, and it has been pronounced by Dr. A. S. Woodward, on the evidence of the fish, to be of Jurassic Age. It is of course possible that this deposit may be the equivalent in age of the water-bearing rocks of the artesian basin, in which case the latter would be newer than Triassic.

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[1] The Fossil Fishes of the Talbragar Beds. Memoirs Geol. Sur. N. S. Wales, Palæontology No. 9, 1895.

A SIMPLE FORM OF SPRENGEL VACUUM PUMP.

By J. A. POLLOCK.
Professor of Physics in the University of Sydney.

[*Read before the Royal Society of N. S. Wales, October 2, 1907.*]

A simple Sprengel vacuum pump which I have designed, has been used in the Physical Laboratory of the University of Sydney for some years and has proved convenient; a description is now given, as possibly the form may be found useful by other experimenters.

The apparatus is a modified short fall Sprengel. The feature of the pump, which is believed to be new, is that the raising of the mercury, necessary for continuous working, is effected by evaporating the mercury at a lower and condensing it at a higher level. This principle may be equally well applied to other forms of vacuum pumps.

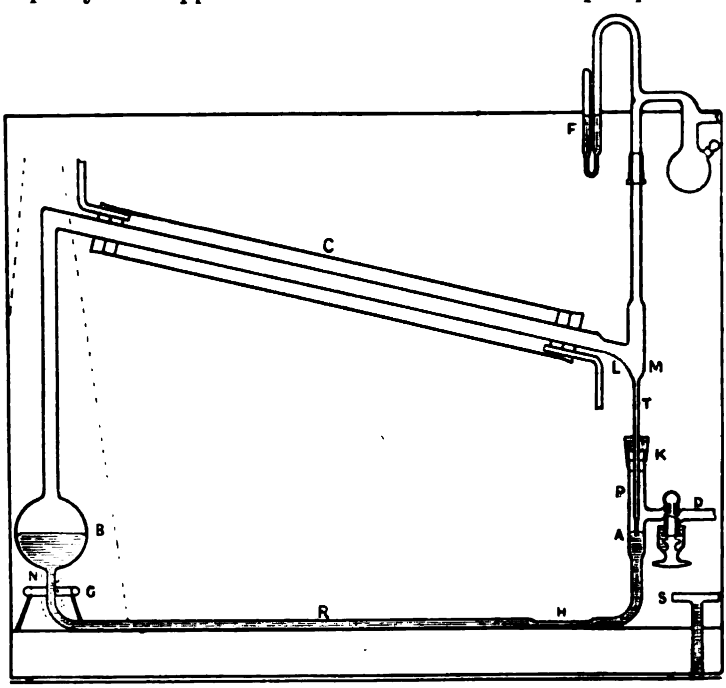

Figure 1, p. 140, is a sketch of the pump, in section, drawn to scale, one eighth the full size. Though the dimensions are not of importance in this instance, the diagram sufficiently shows those which have been found suitable. The apparatus, which is all of glass, is fastened to a board resting on a wooden base, which can be tilted by screws, one of them being shown at S. B is the bulb in which the mercury is boiled by means of the heat from the flame of the gas ring G. From this the mercury vapour passes upwards and is condensed in the Liebig's condenser C. The drops of condensed mercury roll down the inner tube of the condenser into the fall tube T, there carrying the gas from the vessel to be exhausted before them, the gas escaping through the mercury seal at A into the pipe D, which is connected with an auxiliary pump, and the mercury flows back into the bulb B by the tube R.

In such a pump the mercury passing through the fall tube is always clean; the mercury simply circulates round the apparatus, touching only glass, without passing through any taps, and is never in contact with air. The auxiliary pump should be easily worked and capable of exhausting rapidly to a pressure of a millimetre or less of mercury, a Geryk oil pump being admirable for the purpose. If a less efficient pump is used, the seal of the fall tube becomes longer, entailing compression of the gas bubbles and introducing the risk of their not being carried right through by the falling drops.

The vessel to be exhausted is fused to the tube of the drying flask shown at the right hand top corner of the sketch, the flask and gauge F being attached by a glass tube to the fall tube T. The connecting tube is comparatively long to minimise the danger of mercury vapour passing over into the vessel to be exhausted. The small bore tube T, similar to those used for the fall tubes in any

Sprengel pump, passes through a mercury sealed cork at K. At D there is a mercury sealed tap and at H a short length of small bore tube to prevent 'pumping' of the mercury surface at A. An asbestos cone, shown in section in dotted lines in the diagram, surrounds the bulb and vertical tube and a short asbestos tube protects the neck of the bulb N.

In starting the pump, the base of the instrument is tilted until the end of the fall tube T is above the mercury surface at A. The auxiliary pump is then worked, and the whole apparatus exhausted as far as possible by this means. The base is then re-levelled until the end of the fall tube is sealed by the mercury at A to any desired amount, the mercury boiled at B, ordinary precautions being taken against sudden heating, and the final exhaustion effected by the passage of the drops of mercury through the fall tube. During this latter process the auxiliary pump need only be worked intermittingly to remove the small traces of gas which are carried over into the chamber P. The current of water through the outer tube of the condenser should be started before the inner tube gets heated by the mercury vapour.

If arrangements are made for the intermittent or continuous slow action of the auxiliary pump, when the flame of the gas burner has been adjusted to evaporate the mercury at a sufficiently rapid rate, the pump will work indefinitely without further attention, provided the supplies of gas to the burner and of water to the condenser are unaltered. If air has to be admitted to the apparatus, the base must first be tilted until the end of the fall tube is clear of the mercury surface at A.

The form of the condenser is not important; the one shown in the drawing is that which was adopted after some trials. In such a one the slope of the inner tube is

a matter of some moment; if it is too great, the drops of mercury roll down too rapidly and break when they hit the side of the glass at M; if too small the drops coalesce, becoming unnecessarily large and the rate of exhaustion is slow. The shape of the corner of the tube at L should be such as to offer no obstruction to the motion of the drops but to allow them to roll over on to the mouth of the fall tube without hitting the side of the glass at M. If the motion is checked the drops collect together, become uselessly big and the intervals between drops in the fall tube are too long.

The glass blowing for the various pumps which have been constructed in connection with the experiments to fix the details of the design has been carried out by Mr. Carl Sharpe, assistant in the laboratory. The glass working presents no difficulties if the pieces are assembled with the aid of a hand oxyhydrogen burner.

ON THE INTERNAL STRUCTURE OF SOME GOLD CRYSTALS.

By A. LIVERSIDGE, LL.D., F.R.S.
Professor of Chemistry in the University of Sydney.

[With Plates X.-XII.]

[*Read before the Royal Society of N. S. Wales, October 2, 1907.*]

THE specimens figured and described in this note consisted of some groups of crystals, and two simple fairly well developed rhombic dodecohedra, from places in New South Wales, South Australia and Queensland.

The nugget photographed on *Plate* X, came from the Rockhampton District, Queensland, and although it is more or less completely bounded by faces, these appear to be merely the bounding surfaces of the cavity in which the gold was deposited between quartz crystals lining a small vug or hollow. It weighed 35·7 gm. and the quartz crystals removed by hydrofluoric acid weighed 1·63 gm.

The nugget enclosed well developed hexagonal crystals of quartz; these were dissolved out by hydrofluoric acid, and the cavities showed that the prisms were capped by equally well formed pyramids; as it was not possible to obtain good photographs of the pseudomorphous cavities, a mould was taken in flexible glue; this mould was coloured with white paint and photographed, with the results shown in figure 2, *Plate* X. The pyramidal terminations, however, are imperfect from the mould having broken slightly in removal. This is the only example I have come across of well formed quartz crystals enclosed in gold; whereas pieces of irregular quartz vein stuff are very common in gold nuggets.

Figure 1 shows a cut and polished section of the gold; the principal cavities left in it after removing the quartz crystals by hydrofluoric acid, are indicated by arrows as they do not come out very well in the photograph. The chief point, however, is that the gold does not show the presence of concentric layers round the quartz crystals, as might have been expected, nor does it show a well marked crystallized structure; it, however, presents a silky sheen, due probably to the same canse as the sheen in Satin Spar and other similar minerals.

Two gold crystals, well formed rhombic dodecahedra, from New South Wales, are shown enlarged in *Plate* XI, figures 1 and 2. Figures 3 and 4 show the same crystals, but the faces in each have been filed down, polished and etched.

These sections show that these simple crystals are by no means equally simple internally, as seen by the light and dark portions of the photograph. The right hand and lower rhombic faces of figure 3 are apparently cut across by the line *a*, *b*. This same single face is shown enlarged to 18 diameters in *Plate* XII, figure 1, where it looks almost like two faces of an octahedron; a secondary crystal has been brought out in the etching at A. The dark appearance of the right hand half of the rhombic face is due to the way the light is reflected, for both halves presented the same brilliant lustre and colour. The dark lines 1, 2, 4, which look as if made with ink probably indicates a change in the process of growth of the crystal and perhaps of composition also. The cloudy appearance on the edges is due to the portions of the crystal being necessarily out of focus.

Figure 1, *Plate* XII, is a section through a part of the nugget from Tetulpa, South Australia; externally this appeared to be made up of two conjoined octahedral crystals, but the internal structure is seen to be much more complex. The more or less curved and irregular lines are due to the action of the file, for although they were rubbed out during the process of polishing they reappeared in part on etching: the strain or drag from the action of the file seems to penetrate into the soft gold to some depth, this was also found to occur in other cases, and notably in the section of the ingot of pure gold figured and described in the Journ. Chem. Soc., 1896, and the Journ. Roy. Soc., New South Wales, 1894.

NOTES ON THE ARRANDA TRIBE.

By R. H. Mathews, L.S.,
Associé étran. Soc. d'Anthrop. de Paris.

[*Read before the Royal Society of N. S. Wales, November 6, 1907.*]

In the following monograph it is proposed to supply a few notes on the beliefs and sociology of the Arranda tribe, located upon the Upper and Middle Finke River, partly in the Northern Territory and partly in South Australia. The information is either wholly new or is in extension of fragments previously published by others, whose works are quoted.

If this article and my contribution of the 7th August last be studied together, they will be found to present a condensed account of the leading elements of the sociology of the Arranda and Chingalee tribes, in both of which descent is counted through the mother, quite irrespective of the father. Matrilineal descent also prevails in all the eight section tribes from the north-western portion of Queensland, right through a wide zone of the Northern Territory, into the Kimberley District of Western Australia. Tribes with four sections in their social structure, and having matrilineal descent, occupy more than half of the entire area of Western Australia.

Mr. N. W. Thomas assumes that the tribes of the four-section system in Western Australia have patrilineal descent,[2] but I am at a loss to know upon what grounds he does so. My reports just quoted are conclusive that descent is through the mothers.

[1] Proc. Amer. Philos. Soc., Phila., xxxix., 574 - 578, with map; also p. 124. Queensland Geographical Journal, xix., pp. 52, 53; *Ib.*, xxii., p. 78. This Journal, xxxv., p. 220.

[2] "Kinship and Marriage," (London, 1906), p. 40.

Birth and After-life.

I have in former articles briefly referred to the ignorance of the natives of the Northern Territory in regard to the mechanism of procreation, giving examples from the Wombaia,[1] Chingalee,[2] Chauan,[3] Warramonga,[4] and Yungmunni[5] tribes. According to the Arranda belief, a woman may be camping with her husband close to a certain rock, soakage, etc., and a spirit child will come out of the ground, or from the rock, etc., and will throw a tiny tjurunga at her where she is lying asleep. This magical implement enters the woman's body and becomes a child.[6] Another version of this belief is that a woman, whilst out walking in the bush, may pass near to a certain tree where a little spirit child is nestling among the leaves, and it throws a small invisible tjurunga with the same result. Clumps of mistletoe growing on the branches of gum trees are believed by the blacks to be favourite dwelling places of spirit children in quest of a human mother. It is also believed that spirit children are borne along in whirlwinds, and if they pass close enough to a woman will cast a small tjurunga at her in the way described. These mythic infants are very diminutive and may be in the form of any sort of creature, or even invisible altogether.

In the Arranda tribe a tjurunga is allotted to every child, whether male or female, shortly after its birth. If the old men know of a spare tjurunga belonging to the place where the spirit child entered the woman's body, it is conferred upon the new arrival; if not, a new instrument is made and in either case is placed in the knanakala, an unfre-

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[1] Queensland Geographical Journal, xx., p. 73. [2] *Ib.*, xxii., pp. 75, 76.
[3] This Journal, xl., p. 110.
[4] American Antiquarian, xxviii., p. 144.
[5] Bull. Soc. d'Anthrop. de Paris, vii., Serie v., p. 171.
[6] Compare with quotation from Rev. Geo. Taplin, given at p. 112 of Vol. xl., this Journal.

quented spot where these sacred amulets are kept, out of the reach of women or the uninitiated.

Rev. L. Schulze, in speaking of deaths among the Arranda, says the souls of all go to *laia*, a mythical lake situated north of Hermannsburg, on whose shores the souls live, eating fruit and other good food, which is found there in abundance. Mr. Schulze gives another version of the resting place of the departed. He says the *ltana*, ghost, goes away to the *tmara altjiri*, or place where the mother of the dead person was born.[1] He remarks that the natives were unable to explain the variation in the two statements.

During several years past I have been endeavouring to obtain from my correspondents full details of the native belief in an after life, but in carrying out this work they were beset with numerous difficulties. It was hard to make the natives understand what information was wanted about the disposal of the soul or ghost, and when that had been partially overcome, it was found that the native notions in regard to the soul generally were not very clear or well established. In these matters, as in their legends, their views possess a childlike simplicity, natural enough in a primitive people.

Instead of a lake, as reported by Mr. Schulze, some of my correspondents say that the souls go to subterranean caverns, where there are running streams, plenty of food, and sunny days. These mythical places are supposed to be situated a little way beneath the surface of the portion of the tribal territory occupied by the local division to which their mothers belonged. The spirits come up out of the ground and sit in trees or rocks, or journey about in whirlwinds. Although the weight of evidence seems in favour of reincarnation of the original stock of spirits, yet we find

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[1] Trans. Roy. Soc. S. Aust., xiv., pp. 238 and 244.

natives in the Arranda, Loritya, and Erlistoun tribes, as well as among the Chingalee and their neighbours, who state that a spirit child is only born once of a human mother.[1]

Some of my friends found a confirmation of the belief recorded by Mr. Schulze, that when a man dies, his spirit part goes back to the tmara altjira. Altjira means anything mysterious or which has been handed down from unknown times; or something which a native cannot understand or account for. Tmara means a camp, and in an extended sense also signifies the district in which a native dwells. Tmara altjira may be translated as the dwelling-place of one's people, right back to the mythical past.

The Arranda have a tradition that in ancient times the people were shapeless creatures and all of one sex, until a lizard man, whose name was Mangarkunjerkunja, took a sharp stone and by a surgical operation differentiated them into males and females as they are now. This is very similar to a legend reported by Mr. S. Gason in 1874, as existing among the Dieyerie tribe respecting lizards called Moonkamoonkarilla.[2] Among the Parnkalla natives at Port Lincoln, 700 miles south of Hermannsburg, a lizard was accredited with the same functions, according to the Rev. C. W. Schürmann.[3]

The Arranda natives believe in evil spirits called Taturatura, of imaginary forms, who injure men, women or children during the darkness. The souls or spirit parts of living people also wander about at night to extract the fat of their enemies.

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[1] Queensland Geographical Journal, XXII., pp. 76 and 79.

[2] The Dieyerie Tribe, republished in "Native Tribes of South Australia," pp. 260 and 283.

[3] The Aboriginal Tribes of Port Lincoln, republished in "Native Tribes of South Australia," p. 241.

Sociology.

In an article read before this Society on 7th August last I very briefly referred to the sociology of the northern portion of the Arranda tribe, with eight intermarrying divisions.[1] I now intend to shortly describe the sociology of the southern branch of that tribe, in which there are four divisions, instead of eight, as follows:

Table A.

Cycle.	Wife.	Husband.	Offspring.
A	Purula	Pananka	Paltara
	Paltara	Kamara	Purula
B	Pananka	Purula	Kamara
	Kamara	Paltara	Pananka

In 1877 a Mission Station was established at Hermannsburg on the Finke River, in the territory of the southern branch of the Arranda. To this Mission Station there also came natives from the northern part of the country with eight partitions in their sociology. The two parts of the Arranda nation, the northern and the southern, which we may provisionally distinguish as Factions, for want of a better name, never became quite consolidated, although they intermarried and mixed freely with each other. The northern faction pursued the laws of marriage set out in Tables I and II of my paper of August last; whilst among the southern faction the four section system shown in Table A above, was considered the primary or fundamental one, and the additional four sections of the northerners were merely looked upon as complementary.

It now becomes necessary to introduce a table showing actual examples of the marriage of individuals who are all well known to my correspondents.

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[1] This Journal, Vol. xli., pp. 67 - 70, Tables I and II.

Table B.

Section of Individual's Father.	Individual answering the questions.			Section of Individual's Children.
	No.	Proper Name.	Section.	
Pananka Purula	1 1A	Paiarola Ndatjika	Paltara Mbitjana	Knuraia
Knuraia Ngala	2 2A	Jonathan Emily	Paltara Mbitjana	Knuraia
Knuraia Purula	3 3A	Thomas Katarina	Paltara Mbitjana	Knuraia
Bangata Mbitjana	4 4A	Jakobus Lydia	Panaka Ngala	Bangata
Pananka Purula	5 5A	Makana Nakara	Bangata Kamara	Pananka
Kamara Paltara	6 6A	Toby Mathilde	Purula Mnuraia	Kamara
Kamara Paltara	7 7A	Johannes Maria	Purula Knuraia	Kamara
Ngala White man	8 8A	Abel Ruby	Mbitjana Kamara	No child

In the above table, Nos. 1 to 7 indicate the pedigrees of seven married men, all of whom are united to alternative or No. II wives. An explanation of one of the married couples will answer for all the rest. Paiarola, No. 1 in the table, is a Paltara, and is married to Ndatjika, a woman of the Mbitjana section instead of to a Kamara woman. That is, he has an "alternative" instead of a "tabular" spouse. It is also noticed that the descent is not in accordance with Table I of my article of August last, but the children are Knuraia instead of Pananka. In examining the marriages Nos. 2 to 7 inclusive, we find that each man has an alternative wife, and also that the children do not follow the table referred to.

It will require a little explanation to make this variation in the descent clear. If we were to study out Table A we would discover that the section name of the child corresponds with that of its father's father, as well as that of its mother's mother, just the same as in the four sections of the Kamilaroi tribe. When the southern faction amalgamated with the northern, the four additional sections of the latter were treated as complementary of the four primary sections in Table A. For example, when Paiarola married Ndatjika, although she was a Mbitjana woman, she was considered the complement or equivalent of Kamara. Her children consequently would be ranked as Kamara's children, and take the section name of Knuraia instead of Pananka. Looking at Table B we observe that Paiarola's father was Knuraia; and if we refer to Table I of my paper of August last, it can be shown that a Mbitjana's mother must be a Knuraia. Therefore the child of Ndatjika and Paiarola has been given the section name of its mother's mother as well as that of its father's father. The offspring of the married pairs Nos. 2 to 7, receive their section names in the same way.

Further study of Table B teaches us that Ndatjika's father must have married an alternative wife to enable him to be the father of a Mbitjana woman. No. 3A, Katarina, likewise had a father who must have married an alternative wife. These two examples are interesting and valuable, because they illustrate that Ndatjika's mother was an alternative wife like herself, and that Katarina's mother also had the same status as herself. The men Nos. 1 to 7 inclusive have alternate wives, and the two additional examples just mentioned bring the total up to nine men who have married alternative or No. II wives.

In 1898,[1] when confirming Rev. L. Schulze's report of the "alternative" marriages, I had not sufficient information

[1] This Journal, XXXII., p. 72.

to enable me to clear up his statement that "whether Paltara has a Kamara or a Mbitjana for his wife, the children are Pananka."[1] I was however, able to state that descent was counted through the mothers, instead of the fathers as reported by Mr. Schulze.

At that time I was confronted with the following problems: (*a*) That a certain Paltara man with a Kamara wife had a family of the Knuraia section, like Peter and Rebecca, for example, in Table II of my paper of August. (*b*) That another Paltara man in the same locality, with a Mbitjana wife, had children which also belonged to the Knuraia section, such as Thomas and Katarina in Table A of this brochure. (c) Then again Mr. Schulze said that a Paltara man's children should be Pananka, whether he had a Kamara or a Mbitjana wife.

I had sufficient confidence in my informants to feel assured that every one of these conflicting examples was perfectly true. I then asked my correspondents to send me comprehensive lists of married persons with whom they were well acquainted, going back one generation and forward one generation. The cases (*a*) and (*b*) have already been answered, leaving only (c) to be explained.

The Paltara man of Mr. Schulze's example probably or certainly belonged to the faction of the tribe which had only the four sections exhibited in Table A. By all the traditions of his forefathers his wife should be a Kamara, and if he contracted marriage with a Mbitjana she would be treated as the equivalent or complement of Kamara and her offspring would be classified as Pananka, the same as Kamara's offspring.

It appears, then, that there are three methods of reckoning the descent of the offspring in the mixed community of the

[1] Trans. Roy. Soc. S. Australia, XIV., p. 224.

Arranda. One method is exemplified by the four marriages in Table II, p. 69 of my paper of August last. This practice is in accordance with the tabular marriages of the Chingalee, Binbingha, Wombaia and other northern tribes. Another method is exemplified by seven of the marriages in Table B of this treatise, in cases where a man takes an alternative spouse. This law apparently had its origin in the coalescence of the southern and northern factions of the tribe. A third method, in which descent is counted as in Table A, is a continuance or survival of the old law of the southern branch of the Arranda. In the last two methods, which may be bracketed together, the child receives the section name which corresponds to that of both its father's father and its mother's mother.

Looking at Table B, we discover an example of still another variation in the marriages of the Arranda. Abel, No. 8, is a Mbitjana man, married to Ruby, a Kamara. She is what I have called a No. III wife, in dealing with the Chingalee sociology at p. 71 of my monograph of August last.

Referring to Table I of my paper of last August, we see that the pair of women, Purula+Ngala, are the mothers of the pair of women Bangata+Paltara, and this series recurs in perpetual alternation. Each pair consists of one woman from a primary section in Table A, and another woman from a complementary section in Table I of August last. These pairs could be tabulated as follows:

Table C.

Cycle.	Wife.	Husband.	Offspring.
A	Purula + Ngala	Pananka + Knuraia	Bangata + Paltara
	Bangata + Paltara	Mbitjana + Kamara	Ngala + Purula
B	Pananka + Knuraia	Purula + Ngala	Kamara + Mbitjana
	Kamara + Mbitjana	Paltara + Bangata	Knuraia + Pananka

In the above table, the men of the pair of sections Pananka+Knuraia intermarry with the women of the pair of sections Purula+Ngala, and the children belong to the pair of sections Bangata+Paltara.

It will be convenient to call each of these pairs of sections a "dual" division and speak of it in the singular number. For example, Pananka+Knuraia, the first pair in the "Husband" column, may be spoken as a "dual" husband or father; Purula+Ngala as a "dual" wife or mother; and Bangata+Paltara as a "dual" child. We can now illustrate that the "dual" Bangata+Paltara child takes the section name of its "dual" father's (Pananka+Knuraia's) "dual" father, Bangata+Paltara. We also see that this child takes the section name of its "dual" mother's (Purula+Ngala's) "dual" mother, Bangata+Paltara, being in accordance with the well-known law of the Kamilaroi tribe, in which descent is always in the maternal line.

A few pages back it was pointed out that according to Table A, with only four divisions, the child takes the section name of its mother's mother as well as that of its father's father. In Table C, with each of the four sections duplicated, we find that the succession is the same as in Table A, because a primary and a complementary section are treated as *one*.

In what we may distinguish as "Mr. Schulze's reckoning of descent" that is, where the section of the offspring is the same no matter whether a given man marries a "tabular" or an "alternative" wife, the rules of Table C will meet all the cases Nos. 1 to 7 in Table B. But in those instances where descent is counted as in Table I, p. 68 of this Journal, although a child inherits the name of its father's father in "tabular" marriages, yet when a man takes an "alternative" wife the succession of the father's

father's section is extinguished, just as it is in the Chingalee, Wombaia, Binbingha, Chauan and other tribes.

This can be better illustrated by taking an example from Table I, p. 68. If Pananka marries his "tabular" wife Purula, the child will be Bangata, the same section name as its father's father; but if he marries his "alternative" wife Ngala, the child will be Paltara, regardless of Pananka's father Bangata. That is, the name of Pananka's child varies according to which of the two women he marries, because the section names have succession in a prescribed rotation through the women, as stated in the explanation of Table I, p. 68. This is the law of the northern faction of the Arranda.

Among the southern faction, as we have seen above, it is necessary, in "alternative" marriages, according to "Mr. Schulze's method," that the child shall take the section name of its mother's mother as well as that of its father's father, as illustrated in the marriages Nos. 1 to 7 in Table B. This law is in accord with that of the Kamilaroi, and therefore we are justified in saying that the child of an "alternative" wife likewise obtains its section name through the mother.

Spencer and Gillen state that "in the Arunta (Arranda) and in all the tribes from there to the Gulf of Carpentaria descent is counted in the paternal line."[1] By means of thoroughly reliable correspondents, I have been working the Arranda, Warramonga, Chingalee, Binbingha, Wombaia, Warkaia and other tribes since 1895, and have published the results of my labours at various times from 1898 until now. I am satisfied that in all the tribes mentioned descent is counted through the women and not the men.

Spencer and Gillen in speaking of what I have distinguished as "alternative" marriages among other tribes

[1] Northern Tribes of Central Australia, p. 74.

say: "This custom is not met with in the tribes forming the Arunta (Arranda) nation."[1] Table B of the present monograph will be a sufficient refutation of such an assertion.

Professor Spencer says: "Mr. Mathews deals with the organisation of certain tribes in the northern parts of Central Australia. In every tribe he arbitrarily arranges the subclasses (sections) to fit in with maternal descent. In every case in which I have been able to test Mr. Mathews's description of the organisation I have found that either his information or the conclusion which he has drawn from it, is incorrect."[2] If what has been said in the present article, and in the one of August last, cannot be controverted, it will be found that it is Spencer and Gillen's conclusion which is incorrect and not mine.

The Arunta (my Arranda) tribe are reported by Spencer and Gillen to have assembled at one place for "more than four months."[3] A statement of this kind, without an explanation of the circumstances, has misled some English writers into the belief that the Arunta natives possess a higher degree of culture than other Australian savages, to enable them to provide food for such a large assemblage at one spot for so long a time.[4] The facts of the case are briefly as follows:—Spencer and Gillen established a depôt at Alice Springs, and invited the aborigines of the surrounding country to meet them there. All the people of both sexes who came in response to the invitation were provided with a liberal supply of food, clothing, cooking utensils, edged tools of iron and steel, personal ornaments, and everything which was likely to conciliate and please them. In return for this kindness, the conditions were that the

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[1] *Op. cit.*, p. 107.
[2] Rep. Austr. Assoc. Adv. Sci., x., p. 380.
[3] Native Tribes, pp. 118 and 272.
[4] Secret of the Totem, pp. 88, 89.

natives should rehearse all their old ceremonies of every kind, and explain their marriage, burial and other customs, as well as describe all matters upon which information was sought.

Such an extensive programme necessarily occupied a considerable time—apparently more than four consecutive months. It is unnecessary to repeat the well known fact that the habitat of the Arunta tribe is a dry and arid country, in which animal and plant life is of the most scanty and precarious description. It is probable that all the people assembled would have died of starvation in less than a fortnight if they had been depending upon the natural food products of the forests and plains of that locality. Moreover, it is not unlikely that the wise men of the Arunta prolonged all the details of the meeting to their utmost limit, in order to extend their sojourn in such a veritable "Tom Tiddler's Ground."

Boy Companions for Men.

Several of my most trustworthy correspondents, who have resided many years in different places in the Northern Territory and in the northern and central portions of Western Australia, inform me that unmarried men are generally accompanied by young boys, who are allotted to them by the old men. No man has the privilege of obtaining a boy until he has himself passed through the ceremonies of circumcision and subincision. The boy is a brother, actually or collaterally, of one of the woman whom the man will be permitted to marry by and by. Such a boy's mother, therefore, is the potential mother-in-law of the man, and consequently he must neither speak to nor look at her.

This custom has given rise to a widespread belief among the white population that pæderasty is practiced; but from very careful inquiries made by friends at my request, I am

led to the conclusion that the vice indulged in between the man and the boy is a form of masturbation only. A resident of the Victoria River informs me that girls who are too young to admit of natural intercourse with them are sometimes used by the men in precisely the same manner as the boys, except that the little girls do not accompany them. I have original descriptions of how the vice is carried out, but the details are not suitable for publication.

Mr. E. T. Hardman, during his travels in the Kimberley district of Western Australia in 1883-4, observed the custom of single men being presented with what he calls "a boy wife." He says: "There is no doubt they have connexion, but the natives repudiate with horror and disgust the idea of sodomy."[1]

Mr. A. G. B. Ravenscroft published some details in 1892 of this practice among the Chingalee tribe at Daly Waters in the Northern Territory, which go to confirm my statement that the indulgence is practically masturbation.[2]

Conclusion.

In consequence of some important differences of opinion between Dr. A. W. Howitt and myself regarding descent in certain tribes I think it right to bring a few of our conflicting conclusions under the notice of other investigators.

In his "Native Tribes of South-east Australia," Dr. Howitt refers to the Kumbainggeri tribe on the east coast of New South Wales, and after mentioning the four intermarrying divisions, says: "It is not possible to say how these four subclasses (my sections) are placed in pairs representing the two moieties of the tribe, without which knowledge it cannot be said whether descent is in the male

[1] Proc. Roy. Irish Academy, Series 3, Vol. I., p. 74.
[2] Trans. Roy. Soc. S. Australia, Vol. xv., p. 121.

or the female line."[1] He places the Kumbainggeri amongst others under a general heading of "Tribes with male descent."

In 1897[2] and again in 1901[3] I published a table of the four intermarrying sections of the Kumbainggeri tribe, exhibiting how the sections are divided into two phratries or cycles, and supplying lists of totems belonging to each cycle. I stated that "the rules of marriage and descent are precisely the same as in the Kamilaroi tribe." I showed that Kurpoöng corresponds to Murri, Marroöng to Kubbi, Wirroöng to Ippai, and Womboöng to Kumbo of the Kamilaroi divisions. I also pointed out that whether a woman of the Womboöng section marries a Kurpoöng or Marroöng husband, her offspring is always Wirroöng, thus illustrating the alternative law of marriage, as well as the normal or tabular law.

Having been engaged in sociological, linguistic and other investigations among the Kumbainggeri natives for a number of years, I am unwilling that Dr. Howitt's assertion that "the line of descent cannot be given" should go forth uncontradicted, especially as my works above quoted have made it indisputably clear that descent of the sections and totems is counted through the mother in all cases.

Dr. Howitt states that the tribes on the Brisbane River and at the Bunya Bunya ranges have descent in the male line.[4] In 1898 I reported that in both the tribes mentioned descent is counted on the female side, the children always taking the phratry (cycle) and totem of their mother.[5]

In 1883 Dr. Howitt published a table of the four intermarrying divisions of the Mycoolon tribe, stating that

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[1] *Op. cit.*, pp. 165 and 269.
[2] This Journal, xxxi., pp. 169, 170.
[3] Queensland Geographical Journal, xvi., p. 41.
[4] Native Tribes of South-east Australia, pp. 136, 137 and 229.
[5] Proc. Amer. Philos. Soc., Phila., xxxvii., pp. 328 – 331, with map.

descent was through the father.[1] In 1898 I contradicted that statement and showed that descent is maternal.[2] Dr. Howitt in his late work, "Native Tribes of South-east Australia," does not allude to my contradiction, from which it may be inferred that he maintains his statement of 1883. Whether he does so or not, it becomes necessary for me to repeat that I am quite certain that descent in the Mycoolon tribe is indisputably maternal.

I wish to make a few further remarks on Table VI of my monograph of August last, which represents Spencer and Gillen's table of the Chingalee intermarriages. These co-authors profess to have discovered that the first four men in the "Husband" column of Table VI are called by the collective name of *Willitji*, and that the remaining four men in that column are known as *Liaritji*, thus constituting two independent moieties, in which the fathers are said to pass on their moiety and section names to their sons from generation to generation. This succession holds good only while the four men marry No. I or No. II wives, but breaks down altogether when we examine the progeny of No. III or No. IV wives. For living examples of these four sorts of wives, see Table IV, p. 72 of this Volume.

For example, let us suppose that each of the said "Husbands" of the so-called Willitji moiety marries a No. III wife. Then Chimitcha marries a Chuna woman and his son is Chemara; Chuna espouses Chimitcha and his son is Champina; Tungaree weds Taralee and his son is Chula; and Taralee marries a Tungaree wife and his son is Chungalee. These four sons belong to the moiety which Spencer and Gillen call Liaritji. If the four "Husbands" of our example had married No. IV wives, the result would have been the same.

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[1] Journ. Anthrop. Inst., London, XIII., p. 346.

[2] This Journal, XXXII., pp. 82, 88.

It is evident that half of a man's possible wives and half his possible families belong to the Willitji moiety, and half his possible wives and families to the Liaritji moiety—the section and the moiety of the children depending altogether upon the mothers in every case. Whatever may be the meaning of the terms Willitji and Liaritji it is quite clear that they cannot be the names of two independent moieties, because the sons of the Willitji men are liable to be scattered up and down through all the sections of the entire community. Exactly the same confusion will arise if we take our example from the four "Husbands" comprising the Liaritji moiety, see Table VI, p. 82. The partition of the men into the two parts Willitji and Liaritji utterly fails either to prove descent through the fathers, or to establish exogamy of such moieties. These facts also controvert the conclusion arrived at by Mr. N. W. Thomas when he says: "The existence of phratriac [moiety] names enables us to say definitely that the descent in this tribe is in the male line."[1]

Corrections.

In Vol. xxxiv of this Journal, p. 129, and in Vol. xxxv, p. 218, I reported a variety of totems appertaining to some tribes about Cresswell Downs, Sturt's Creek and adjacent country. The information was gathered for me by Mr. Innes, Mr. Stretch, Mr. Wilson and other residents of those regions. Upon continuing my inquiries through these men and gathering further details, I find that the totems are not arbitrarily attached to the particular pairs or quartettes of sections mentioned in my former papers. All the totems therein enumerated are found among the different sections, but instead of being inherited from either parent, are determined by the locality where the mother first became aware that she was enceinte, in accordance with the beliefs

[1] Kindship and Marriage, p. 150.

reported in my account of the Chau-an tribe in this Journal, Vol. XL, pp. 107–111. Metaphorically speaking, it is a certain tree, rock, spring, sandridge, or other natural feature in the family hunting grounds, which produces or bears the child, and confers its totem upon it, instead of these functions being performed by a human mother.

The above correction applies to Vol. XVI, p. 71, of the *Queensland Geographical Journal.*

A SHORT AND ACCURATE METHOD FOR THE ESTIMATION OF IRON, ALUMINA, AND PHOSPHORIC ACID WHEN OCCURRING TOGETHER.

By THOMAS COOKSEY, Ph. D., B. Sc.

[*Read before the Royal Society of N. S. Wales, November 6, 1907.*]

As most of the results obtained by means of the following process depend on the estimation of the phosphoric acid left in the filtrates, I would like to commence this paper by a description of a volumetric method for the rapid estimation of that body which depends upon its precipitation as a tricalcic phosphate.

Some two years ago during an attempt to volumetrically estimate calcium and barium by means of a phosphate solution I found that, in the presence of an excess of calcium chloride, tricalcic phosphate was precipitated whenever the solution became alkaline to methyl orange, and that phosphates could be simply determined by first making the solution, which must contain excess of calcium chloride, neutral to methyl orange, then adding a few drops

of phenol-phthalein solution and noting the amount of standard caustic potash required to produce a permanent pink colour. Care must of course be taken that no carbonates, silicates, or borates are present. Proceeding in this way I found that one molecule of caustic potash KHO was equivalent to one quarter molecule P_2O_5 or one half group PO_4, that is 1 cc. normal caustic potash was equivalent to ·0355 gm. P_2O_5. I at first imagined that this method of estimating phosphoric acid was a new one, but upon looking up the literature of the subject, I found that this process had been proposed and worked out by Emmerling in 1886 and published in "Landwirthschaftliche Versuchs-station," 1886, page 429.

Emmerling, however, applied the principle somewhat differently—The solution containing the phosphate, to which an excess of calcium chloride had been added, was run into a measured quantity of a standard caustic soda solution, until the pink colour given by phenol-phthalein had just disappeared. The number of cc. required was noted; the same quantity of the phosphate solution (containing the calcium chloride) was then titrated with standard caustic soda until, with methyl orange as indicator, the pink colour just disappeared. The number of cc. of standard soda required was subtracted from the amount used in the titration with phenol-phthalein. The difference gave the amount of phosphate in solution. Emmerling states that small amounts of iron and alumina do not interfere with the estimation. This statement from my observation is not strictly true. Very small quantities, such as may occur in super-phosphate of lime perhaps make little difference, but if the quantities of iron and alumina are at all considerable, phosphates or hydrates of these metals are precipitated in arriving at the neutral point with phenol-phthalein. I have used the previously described

modification and simplification in the Government Laboratory for the last two years with very satisfactory results, and it is especially applicable to the estimation of phosphates in the ashes of various kinds of foods, as milk, vinegars, wines, etc., which do not contain iron or alumina. The method in detail is the following:—The ash is dissolved in hydrochloric acid, a drop of methyl orange solution added, and caustic potash run in until the solution is just slightly acid. Carbonic acid is removed by boiling, and excess of calcium chloride and a few drops of phenol-phthalein solution added. The neutralisation of the mixture is carefully adjusted by means of decinormal caustic potash, the point at which the methyl orange just becomes yellow is read off, and the addition of the decinormal potash continued until a slight but permanent pink is obtained. The number of cc. required between these two points gives the amount of phosphate present, 1 cc. being equivalent to one quarter molecule P_2O_5 = ·00355 gm. or one half group PO_4 = ·00475 gm. The great advantage of the method lies in its accuracy and in the rapidity and facility with which it can be carried out. Provided there is excess of calcium chloride present magnesium does not interfere, but iron and aluminium must be absent.

10 cc. of a $\frac{N}{10}$ solution of a phosphate are found to require 6·6 cc. of a decinormal solution of caustic potash; this is the theoretical amount. Of course the standard potash solution must be corrected for the small amount of carbonic acid which it may contain. This is easily allowed for by finding its equivalent against standard acid with phenol-phthalein as indicator.

The estimation of iron and aluminium in the absence of phosphoric acid.—The methods already known for the volumetric estimation of iron can hardly be improved upon, and the one adopted in the following process of analysis

depending on the liberation of iodine from potassic iodide by a ferric salt gives very accurate results. The iodine is estimated by thio-sulphate and one atom of iodine is equivalent to one atom of iron. The method is very simple, quick, and easily carried out, but appears, so far as my knowledge goes, to be very rarely used. The only precaution necessary is the avoidance of any oxidising compounds or substances liberating iodine. This condition is in most cases easily obtained. The method is equally good in the presence of phosphates.

A volumetric method for the estimation of alumina, which I have found accurate, depends on its precipitation as phosphate, and estimation of the amount of the phosphate left in the filtrate by means of the method previously described. If a known quantity of phosphate solution be added, the amount precipitated with the alumina is found from the difference between the amount added and the quantity left in the filtrate, and the amount of aluminium is simply calculated from this loss of phosphate. The orthophosphate $Al_2(PO_4)_2$ is formed. This is carried out as follows:—To the slightly acid solution containing alumina, monosodic phosphate is added in known quantity, and a drop of methyl orange. Standard decinormal caustic potash is now run in until the yellow stage is just reached. The whole is warmed to promote the coagulation of the precipitate, cooled, made up to a definite volume, and an aliquot part filtered, the phosphate determined in the latter and therefore in the whole filtrate. The difference between this quantity and the total amount added gives the quantity precipitated as $Al_2(PO_4)_2$ from which the aluminium is simply calculated. Or, if preferred, the precipitate of aluminium phosphate may be washed and the whole of the filtrate used in the estimation of phosphate by the previously described method. Iron, of course, must not be

present. It is preferable to work in dilute solution, say decinormal to centinormal strength.

The estimation is quickly carried out and can also be made use of in the case of iron which is similarly precipitated as the orthophosphate $Fe_2(PO_4)_2$. The phosphates of iron and alumina are insoluble in neutral solutions containing phosphates, and practically insoluble in water.

Example—10 cc. of a solution containing ·0445 of Al_2O_3 were put into a 100 cc. flask, 5 cc. of normal monosodic phosphate added, and the whole made up to 100 cc. after neutralising and warming as previously described. 50 cc. were then filtered off through a dry filter.

50 cc. required 8·0 cc. (corrected for CO_2) $\frac{N}{10}$ KOH equivalent to ·0284 gm. P_2O_5, that is to ·0568 gms in the 100 cc.

Total P_2O_5 added	·1183 gm.	calculated	
P_2O_5 in filtrate	·0568 ,,		
P_2O_5 combined with Al_2O_3 ...	·0615 ,,		
Al_2O_3 corresponding to ·0615 P_2O_5	·0443 ,,	·0445 gm.	

The estimation of both iron and aluminium together in the absence of phosphoric acid can also be effected volumetrically and quickly by means of the same method; the two phosphates are precipitated as previously described for alumina alone, the phosphate in filtrate estimated, and the difference between this amount and the amount of phosphate solution added gives the phosphoric acid combined with iron and alumina. An estimation of the iron in original solution by means of the iodine method gives the other factor necessary—knowing the amount of iron and the total phosphoric acid in the precipitate, the alumina is calculated. In case of any disturbing elements in original solution, the iron can be simply estimated by dissolving up the precipitate and proceeding as before with the iodine method.

Examples—	I.	II.
Fe_2O_3 found by iodine thio-sulphate ...	·0386	·0384
P_2O_5 in filtrate	·1406	·1413
Total P_2O_5 added to solution	·2366	·2366
P_2O_5 in filtrate	·1406	·1413
P_2O_5 combined with Fe_2O_3 and Al_2O_3 ...	·0960	·0953
Calculated P_2O_5 combined with Fe_2O_3 found above	·0342	·0340
P_2O_5 combined with Al_2O_3	·0618	·0613
Al_2O_3 calculated from last figures ...	·0446	·0443
Al_2O_3 in solution (mean of 5 determ. as Al_2O_3)	·0445	

Estimation of iron and alumina by weighing as phosphates.—Both iron and alumina can be accurately estimated by precipitating the phosphates of these metals in the manner previously described and given more in detail later. The method is more especially useful in the estimation of alumina when occurring with phosphoric acid.

Estimation of Iron.

Example—

a. $Fe_2(PO_4)_2$ ·0766 equivalent to	·0407	Fe_2O_3
b. $Fe_2(PO_4)_2$ ·0761 equivalent to	·0403	Fe_2O_3
Fe_2O_3 found by iodine and thio-sulphate	·0404	Fe_2O_3
Fe_2O_3 by weighing as such	·0408	

Estimation of Alumina.

Example—$Al_2(PO_4)_2$ ·1620 equivalent to	·0678	Al_2O_3
Al_2O_3 by weighing as such ...	·0680	

The estimation of iron, aluminium, and phosphoric acid when present together in solution.—The estimation of these three substances when occurring together has always been a somewhat lengthy operation and is usually carried out by the preliminary precipitation of the phosphoric acid by means of ammonic-nitro-molybdate. Other methods are available, but in any case the processes are tedious and a

shorter method of analysis is certainly much to be desired. Aiming at this object, I have suggested the following method, which appears to me to greatly lessen the amount of work and time occupied in obtaining the desired results.

The method is an adaptation of those previously made use of, but as the amount of phosphoric acid already in solution is an unknown quantity, another factor has to be sought in carrying out the calculation. This is supplied by the weight of the mixed phosphates of iron and alumina. The method is as follows:—To the solution, which must be sufficiently acid to produce a yellow colour and not a reddish one with the iron present, is added a definite quantity of a standard solution of sodic dihydric phosphate. In case the original solution is too strongly acid, this can be partially neutralized by caustic potash or by evaporation; and it is convenient to work with 20 or 30 cc. of solution containing not more than ·1 gm. of the mixed oxides. With this amount of liquid, the precipitation can be conveniently carried out in a 100 cc. flask. Caustic potash of decinormal strength is gradually run in under constant shaking until the pink tint with methyl orange has just disappeared. The volume is made up to 80 or 90 cc. and warmed for a short time on the water bath. This heating causes the precipitate to coagulate and quickly settle. The precipitate is now filtered off and well washed with hot water until the filtrate gives no cloudiness with silver nitrate when tested for chlorides, assuming them to be present. A few more washings after this stage is arrived at, thoroughly stirring up the precipitate on the filter, are then sufficient. The filtrate and washings together will then make 200 or 250 cc. Calcium chloride in excess is added, the whole made slightly acid to methyl orange by a few drops of decinormal hydrochloric or sulphuric acid, and boiled to get rid of any carbonic acid. The procedure is

the same as that previously described. The precipitated phosphates are dried, and can be removed from filter paper, the latter burnt off in platinum crucible at low temperature and the remainder of precipitate added. The whole is then heated by Bunsen burner to constant weight. It is perhaps advisable not to raise to too high a temperature. The iron can be separately estimated either in the original solution or by dissolving up the phosphates with a few drops of strong hydrochloric acid and making use of the iodine and thio-sulphate method.

We have now the weight of the total iron and aluminium phosphates, the amount of iron, and the amount of phosphate left in solution. The amount of *iron phosphate* corresponding to the oxide of iron found, is subtracted from the total weight of phosphates, the difference gives the aluminium phosphate. By subtracting the known quantity of phosphoric acid added, from the sum of the three amounts of phosphoric acid found, that is, that combined with the iron, that combined with the alumina, and the amount left in filtrate, we obtain the original phosphoric acid in solution.

Examples—To the solution to be tested were added in each case 10 cc. normal phosphoric acid solution equivalent to ·2366 gm. P_2O_5.

	I.	II.
Iron oxide, found by iodine method in the ppt.	·0384	·0386
Phosphoric acid in filtrate	·1413	·1406
Iron and aluminium phosphate	·1772	·1795
Iron phosphate calculated from amount of iron found	·0724	·0728
Aluminium phosphate by difference	·1048	·1067
Al_2O_3	·0438	·0446

FOUND.

I.			II.		
Fe_2O_3 ·0381	P_2O_5	·0340	Fe_2O_3 ·0386	P_2O_5	·0342
Al_2O_3 ·0438	P_2O_5	·0609	Al_2O_3 ·0446	P_2O_5	·0620
In filtrate	P_2O_5	·1413	In filtrate	P_2O_5	·1406
Total ...	P_2O_5	·2362	Total ...	P_2O_5	·2368

CALCULATED.

Fe_2O_3 ·0386 Al_2O_3 ·0445 P_2O_5 ·2366

In using this method a few precautions, more or less obvious, are advisable in order to obtain good results. The acidity should not be too great, but enough acid should be present to give to the solution a yellow and not a reddish colour in the presence of iron. Monosodic phosphate should be used so that at no time the solution is alkaline to methyl orange during the addition of the phosphoric acid. The standard caustic soda should be added with constant shaking for a similar reason; as the phosphates are easily acted upon by alkaline solutions, losing a part of their phosphoric acid.

In testing an original solution to see if any phosphoric acid is present, it is very easy to get an approximation to the amount of that body in solution by using a method which I have found very useful. This consists in preparing standard tubes containing ·0001, ·0002, ·0003, etc. grms. of P_2O_5 and treating with a few cc. of ammonic-nitro-molybdate, keeping to the same bulk and conditions throughout. These tubes can be sealed off and kept for comparison when required. A rough estimation of the amount of phosphoric acid in a solution can be made by suitably diluting and working with quantities similar to those used for the preparation of the standard tubes, comparing the densities of the precipitate in the cold. When traces only of phosphoric acid have to be estimated, this method gives the most accurate results. The amount of phosphoric solution required to be added to precipitate the iron and alumina can thus be roughly ascertained. The total phosphoric acid in solution need not exceed twice the quantity necessary to form the phosphates of these metals.

In conclusion I wish to express my thanks to Mr. S. G. Walton, Assistant in the Government Laboratory, Sydney, for his assistance in helping me to carry out some of these analyses.

NOTE ON THE FORMATION OF FORMALDEHYDE IN SOLUTIONS OF CANE SUGAR AND ITS BEARING ON HEHNER'S TEST FOR FORMALDEHYDE IN SACCHARINE MIXTURES.

By A. ALEXANDER RAMSAY.

[*Read before the Royal Society of N. S. Wales, November 6, 1907.*]

TRILLAT[1] has shown that on heating cane sugar, traces of formaldehyde are given off even at 125° C. At 150° C. the aldehyde is liberated in greater quantity. Analysis of the vapours emitted at 200° C., shewed the presence of 0·2 to 5·7% formaldehyde, and the residual caramel contained up to ·27% of polymerised formaldehyde, probably in the state of trioxymethylene. The amounts produced were found to vary with the method of heating, the nature of the vessel, and the purity of the sugar.

The object of the present note is to draw attention to the fact, that the production of formaldehyde takes place in minute quantities when cane sugar and water are heated together from 100° to 103° C. This fact renders the Hehner test[2] unreliable as an indication of the addition of formalin to jam or saccharine beverages, since formaldehyde is produced in the manufacture of jam. Moreover, the act of distilling a saccharine liquid, results in the formation of formaldehyde, even if it were not originally present.

The following experiments were performed:—1. 100 grams pure cane sugar was dissolved in 5 ozs. cold distilled water, heated for half an hour, and distilled. The distillate

[1] A. Trillat, "The formation of formaldehyde in the caramelisation of sugar," Bull. Soc. Chim., 1906, xxv., 681 - 685.

[2] Analyst, 1896, xxi., 95.

gave the reaction for formaldehyde, with Hehner's test.[1] The boiling point of the residue in the retort was 103° C.

2. 50 grams pure cane sugar was dissolved in 5 ozs. cold distilled water in a glass retort and heated till the mixture boiled, and distilled. The distillate which was obtained during the first 20 minutes was collected and marked "*a*." The receiver was changed, and the distillation continued for about 20 minutes longer, the distillate collected and marked "*b*." The liquid remaining in the retort was diluted with cold distilled water to 5 ozs., and again heated and distilled—collecting the distillate separately and marking it "*c*." When the distillation was finished, the sugar solution in the glass retort was crystal clear, had no yellow tinge, boiled at 101° C. to 101·5° C., and gave a strong reaction for formalin.

The three portions of distillates marked *a*, *b*, *c*, were tested for formaldehyde by Hehner's test, and all gave the reaction, though faintly. The remainder of portion marked "*a*" was redistilled and the first 5 cc. caught and marked *a′*. This gave a strong reaction for formaldehyde both by Hehner's test and Pilhastry's test.[2]

The remaining portions of distillate marked *b* and *c* were similarly treated, the first 5 cc. of each caught and marked *b′ c′* respectively. Both *b′* and *c′* gave the Hehner reaction for formalin, *c′* less strongly than *a′* or *b′*.

The foregoing taken with Trillat's note, explains the occurrence of formaldehyde in jam made from pure fruit, cane sugar and water. Jam was prepared from pure fruit and pure cane sugar as follows:—

Peach ...	1 lb. fruit,	1 lb. sugar,	3½ ozs. water,	boiled about 2 hours
Orange ...	1 "	2 "	13 pints water,	" 2 "
Quince ...	1 "	¾ "	1 "	" 2 "
Quince Jelly	1 "	1 "	1 "	" 2 "

[1] Analyst, 1896, xxi., 95.

[2] Tests and Reagents—Cohn. John Wiley & Son, New York, 1903, 236.

Unfortunately at the time these jams were prepared, the boiling points of the various mixtures was not noted. The temperature was certainly never above that reached in making jam on the manufacturing scale, and there was no possibility of caramelisation.

On examining the foregoing four jams for formalin (by distilling a portion faintly acidified and testing the distillate) reactions were obtained in all cases—in the case of the orange jam the reaction was particularly strong.

Further investigation as to the amounts of formaldehyde present are being carried out, and the results will be embodied in a future paper. The experiment also shows the unsuitability of the method of examining jams for formaldehyde, by dissolving 50 grams sample in 250 cc. water as recommended by Leach,[1] acidifying with phosphoric acid, distilling and testing the first 30 cc. distillate for formalin. After 125 cc. distillate has been obtained, further distillation yields a distillate containing still larger quantities of the aldehyde.

The presence of formaldehyde in various foods has been noted by Perrier,[2] who finds in cider ·2 to ·33 parts formaldehyde per 100,000, and in bacon, ham, sausage, herring, etc., amounts varying from ·03 to ·003 parts per 100,000. In jams examined by the author the amounts of formaldehyde have varied from 1·3 to 14 parts per 100,000.

The experiment (2) mentioned previously, was repeated with the object of applying other confirmatory tests for the formaldehyde present, by the Gayon-Saglien-Mohler reagent,[3] Philhastry's reagent,[4] Hehner—aqueous phenol,[5]

[1] Food inspection and analyses, A. E. Leach—John Wiley & Sons, New York, 1904, p. 706.

[2] Presence of Formalin in Certain Foods, Perrier, Compt. Rend. 1906, 143, 600-603.

[3] Analysis of Alcohol and Brandy, M. X. Rocques—Rev. Internat. de fals. and d'anal. des Matieres Alimentaires, April 1907, p. 49.

[4] Tests and Reagents, Cohn.—John Wiley & Son, New York, 1903, 236.

[5] *Ibid.*, p. 121.

and Hehner, commercial sulphuric acid.[1] Reactions clear and well defined were obtained by both Hehner's tests and a faint reaction with Pilhastry's reagent, but no reaction with the Gayon-Saglien-Mohler reagent.

While carrying out these tests I found Hehner's milk-sulphuric acid test most delicate; 1 part formalin in 4 millions gave a clear reaction in two minutes, and up to 1 in 10 million on standing a little longer, provided the milk is added to the solution of formaldehyde immediately before the addition of the sulphuric acid. The aqueous phenol and sulphuric acid reacted up to 1 part in 4 millions. Pilhastry's reagent seems to detect only 1 part in $\frac{1}{2}$ million and the Gayon-Saglien-Mohler reagent about 1 part in $\frac{1}{4}$ million.

It has also been shown by Förster[2] that furfuraldehyde is produced in small quantities by boiling sugar with water, but in the experiments detailed above I find no furfural reaction, only formaldehyde. In the case of furfural in dilute aqueous solution with Hehner's test (milk sulphuric acid), at the junction of the two liquids a faint pink zone is formed, which darkens, forming a decided green colour which deepens on standing. With Hehner's aqueous phenol and sulphuric acid test applied to furfural, a purple black band forms at junction of the liquids which deepens in colour on standing and increases in size. These reactions are quite dissimilar to the reactions of formaldehyde.

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[1] *Ibid.*, p. 121.

[2] Förster, Berichte der deutschen Chemischen Gesellschaft, 15, 230 – 322.

THE EFFECT OF POLAR ICE ON THE WEATHER.

By E. Du Faur, F.R.G.S.

[With Plates XIII. - XVI.]

[*Read before the Royal Society of N. S. Wales, December 4, 1907.*]

THE immediate incentive towards the preparation of my present paper was a sub-leader appearing in the *Evening News*, Sydney, of October last, headed 'Icebergs and Weather,' in which the writer stated:—

"There is one source of information which our meteorologists have not tapped, and that is, the weather conditions of the Antarctic Ocean. The prevalence of icebergs in the northern portion of that ocean is supposed to cause a showery summer in the south of New Zealand, followed by plentiful rains in winter, and their influence is acknowledged even in India. In the northern hemisphere, the people of Norway, who depend for their living on the tourist traffic, anticipate the value of the summer's business by the condition of the ice around Iceland. Perhaps Professor David, on his visit to the Antarctic seas, may be able to tell us something more of this important question, and whether the conditions prevailing in those regions—of which floating icebergs are symptomatic—influence our weather during the following year."

On reading this I at once furnished the editor with printed evidence that I had brought this matter before the public, first in a letter to the *Sydney Morning Herald*, of 7th February, 1881, and again more fully in a paper read by me before the Royal Geographical Society of Australasia, in September 1891, on "Antarctic Exploration." Both of these papers are so entirely out of date, that I think I am justified in repeating to a great extent my former words.

In my paper of September 1891, apart from the general subject of Antarctic exploration, and the possibility of a

revival of the whaling and fur-sealing industries in the Great Southern Ocean, by these colonies, I drew attention to "the possible effect of the varying position of floating ice and ice-fields, in that vast area, on the meteorology of the southern portion of our continent; and recorded that, on supplying the *Sydney Morning Herald*, February 7th, 1881, with a translation of a minute received from the Geographical Institute of Berne, respecting the then proposed Italian expedition, I prefaced it with a few remarks of my own, and ventured to express the opinion that:—

"It is from investigation into the sources and direction of Antarctic Oceanic currents, and into the varying disposition of Polar ice, in higher or lower latitudes, in different years, or during more lengthened periods, that we may ultimately hope to arrive at some knowledge of the laws under which our climate is directed. In the constant struggle for mastery, which we know to be carried on between the winds generated in those Polar regions, and by those causes, with equatorial and westerly winds, due to the rarification of the air from the heated surface of this vast continent, in this grand struggle between forces generated altogether beyond her limits, New South Wales must eventually look for the solution and governing laws of periodic successions of dry and moist seasons."

I went on to remark that "ten years ago, (1881) such a movement was, I supposed in advance of the times, as it received some very harmless ridicule from quite an unexpected quarter, and was dropped. But as it now (1891) appears to be more in favour, and a leading article in the *Sydney Morning Herald* of 24th April, 1891, remarked, 'that the meteorology of the Antarctic Circle may be otherwise of deeper interest to us, for there is not the least doubt that in our climatic changes we are closely linked with the meteorological and magnetic conditions of the great Polar region so close to our doors.'"

I should like to refer to some circumstances which many years previously to 1881 led me to the opinions above expressed. In the early fifties, I happened to take an

interest in the Great Circle Route, and in collating the logs of the ocean clippers, then competing for the fastest passage to Port Philip, many of which summaries were from time to time printed in the Melbourne *Age*. I have also a distinct recollection of ice-charts being occasionally published in those years, showing the varying latitudes in which ice had been encountered. (My collection of cuttings and extracts on the subject has, unfortunately, long since been lost or destroyed).

In those days the "Marco Polo," and her rivals, went into high latitudes, seldom I suppose now visited; and that was a comparatively dry period in southern Australia. Later on, in the later fifties, the obstructive ice was met with in so much lower latitudes, that Great Circle sailing was virtually abandoned, on account of the danger; and 1857 (the "Dunbar" year), and several following years formed a comparatively wet period in these colonies; and the conclusion appeared to me reasonable that, when the ice was confined to high latitudes, the northerly and westerly dry winds would have the predominance; when it encroached into lower latitudes (further north) the southerly polar winds would obtain the mastery.

If any such cyclical periods of varying position of the ice limit exist, we may for ever remain in ignorance of the great natural causes of such oscillation; but we can observe and record them for the benefit of posterity, if not for our own. Had the observations which led to the publication of the simple ice-charts of the early fifties been methodically maintained, we should now (1891) have nearly forty years record to show, and might hope to begin to know something on the subject. Unfortunately, the higher latitudes, in the parts of the Great Southern Ocean to the immediate southward of this continent, are seldom or never visited. Whalers, there, are probably unknown, and steam has

practically for ever closed the Great Circle route. Something might be done by collating the experience of homeward-bound ships rounding the Horn, but they only enter high latitudes when many degrees east of Australia; but should the present movement (1891) prove a success, and Antarctic exploration become the fashion, and commercial enterprise follow the right whale to his supposed habitat in the Antarctic ice, would it be too much to expect that a tender, or some fitting vessel of our colonial navy, (when we have one), should, say twice a year, when visiting Hobart (lat. $41\frac{1}{2}$ S.) take a dive further south for a few degrees, and record, in the same months, and on the same meridian, year by year, the limits where dangerous ice is first met. Having previously fully cited the circumstances under which Dumont d'Urville, in January 1840, left Hobart, and penetrated south for some 25 degrees, about 1750 miles, coasted for 210 miles, and returned to Hobart in seven weeks, meeting with no obstruction from land between that port and the Antarctic Circle; it might almost be said that, in these days, with steam as an auxiliary, the voyage would be reduced to less than a month's pleasure trip.

Such records supplemented by all information on the subject obtainable from mercantile and whaling vessels, would be as valuable to future generations in these colonies as a similar record for the past forty years, above referred to, would have been to ourselves.

Quoting again (still in 1891) from the leading article in the *Sydney Morning Herald*, above mentioned:—

"It may be at once admitted that such an enterprise is of the kind that does not appeal very forcibly to that class of mind which asks—what is to be the use of it? regarding any proposal which does not promise a direct return in pounds, shillings, and pence."

And speaking only as an amateur, not as an official meteorologist, my suggestion may elicit many cavils; but after

the patient investigation which our scientists have given to Lunar theories, Sun-spot theories, and other universal theories—if I may use the expression—which, if of any force, must apply equally to all parts of our globe, it does not seem too much to ask them, *as Australians*, to give a portion of their attention, and their best influence, towards carrying out a methodical and scientific investigation into the secrets and changes of the 'gigantic refrigerator'[1] which we have 'comparatively close to our doors,' in constant conflict with the semitropical heated currents generated within our own continent, and into the laws and periods by which either predominating influence affects the climate of southern and eastern Australia.

The Geographical Society of Australasia might commence some useful work by endeavouring, through its kindred society in Victoria, to verify my personal recollections of earlier years; there must be records, in some of the old shipping offices in Melbourne, bearing on the subject, the early files of the *Age* would supply many a clipper's log, and there must be enough of my contemporaries still in existence, who were interested in shipping matters in those days, to make it probable that some of the ice-charts, which I remember, might be brought to light, which would relieve us from beginning again, in these later days, with quite a clean sheet.

For many years subsequent to 1857, absence from the colonies and then the exigencies of heavy official and business life, precluded my watching and recording the trifling data bearing on the subject which the advancement of steaming versus sailing traffic left available. But the proposed Nordenskiold Antarctic Expedition re-awakened

A refrigerator representing a circle of some 4,000 or 4,500 miles in diameter, equal to an area of some 15 or 16 millions of square miles, may fairly be called 'gigantic.' its northern limit extending to within 1,000 to 1,200 miles of Tasmania.

my interest in it. Also in 1888 when Mr. Egeson, working on carefully collated data as to sun-spots, promulgated his forecast that "the following three years would be years of excessive drought in Australia," I did my best to stem the scare which this caused in the pastoral industry, with which I was directly connected. Having noticed that ships, passing between the colonies and Cape Horn, had reported much ice, unusually far north, I very publicly expressed my opinion, based on my earlier observations, "that we might rather expect three years of excessive moisture," in fact, "backing ice-bergs against sun-spots." The three, even four, following years, as it happened, proved to be almost the wettest we had known. On the average, as then standing, of 49·23 inches, 1889 showed 57·26; 1890 81·42 (the maximum on record); 1891, 55·30; 1892, 69·26; in all 66·22 inches, or 16·50 inches per annum, above the previous mean at Sydney Observatory.

My views met then with no official support, the only remark I noticed was one of ridicule—"that the effect of the shifting ice, in the Southern Ocean could have no more to do with the climate of New South Wales than an ice chest in our back yard," However I could afford to wait.

I will make but one extract from recent writers to show how modern data, and the train of modern thought, leave me little to be ashamed of in my early views. The distinguished scientist Baron von Richthofen wrote, shortly before his death in 1905:—

"We can guess that the greater or less heaping up of ice round the poles may explain the changes in the climates of the world. We know, from careful observations, that the beautiful heights of our Alps already show that their ice covering is diminishing. The same thing is taking place in the Andes of Ecuador, and on Kilimanjaro—in the Arctic regions the recession of the ice has been noticed. . . . *All points to a general drying up.* It is

now an important question whether this is also the case in the Antarctic regions. Is this withdrawal observed there, or is it different from what has been observed in the North? . . . At a spot visited by Ross there were exact observations taken, they show that the ice-edge of Ross is now thirty miles further south than it was in his day, and that the glaciers of Victoria Land have gone far back. In Ross' time the glaciers reached the sea, but they no longer do so. The German Antarctic Expedition discovered traces of glacier recession on Gaussberg. It was necessary in order to determine the rapidity of this recession, to decide the present position of the ice by measurement, in order that future observers may be able to ascertain changes that have taken place in an interval of a few years. So far as we can judge, this retirement of the ice-cap is of the highest importance for future generations. Still, at any moment, changes of an opposite character may take place; and to recognise the changes certain lines are necessary, such as were fixed at Gaussberg. . . . Far seeing researches in recent years show that the changes in the distribution of ice, and the changes in the currents of the sea round Greenland have an important influence on the changes of climate in Germany. The time does not seem to be far distant when it will be possible to predict the character of the seasons months beforehand. This is only the beginning of the practical use of these researches."[1]

So distinguished a scientist cannot, in his phrase—'a general drying up' have referred to any great cosmical change, such as we know to have occurred in vast geological periods. I am assured that astronomy points to nothing of the sort in the comparatively trifling era over which its accurate determinations extend. His subsequent remark that 'at any moment, changes of an opposite character may take place,' shows that he referred only to cyclical changes, of unknown period—the see-saw between accumulation and denudation of ice, the necessity for the observation of which he so strongly accentuates, in the

[1] The Geographical Journal, January 7, 1906.

interest of coming generations, as I had done a quarter of a century before.

I assume that most of you are fairly posted up in the literature of Antarctic Exploration during the last twenty years, which from time to time has been so ably summarised by Sir Clements Markham, and other Presidents of the Royal Geographical Society. Previous to this, we were restricted to the data supplied in the early part of the nineteenth century by Biscoe, Bellamy, Dumont d'Urville and Wilkes, ending with the voyages of Captain James Ross, 1841-3, which closed the early history of Antarctic exploration, and was to receive no addition for fifty years. Half a century passed, a nation had arisen in the Australian colonies, almost daily visited by vessels improved to the latest developments of naval architecture, and no longer dependent on the chance winds of heaven for clawing off a lee shore, or beating a hasty retreat from unexpected troubles, and yet it has seemed impossible to awaken any active interest in obtaining further data for our guidance. You will probably allow that I was justified twenty-seven years ago in thinking, that "if any cyclical periods of varying position of the ice-limit exist, we may for ever remain in ignorance of the great natural causes of such oscillation," but my life has been spared long enough to allow me to alter that opinion; the explorations of Lieutenant Peary, United States Navy, in Greenland have shown a gigantic ice cap of unknown depth, 1,000 to perhaps 5,000 feet, covering an area of 25,000 to 30,000 square miles; the present theory appears to be that this great mass, increased every year by successive layers of snow, where rain never falls, and snow never melts, with its superincumbent weight exercises an enormous dynamic pressure on the glaciers and ice-cliffs at its foot, forcing them out to sea in the shape of bergs, which extend some-

times to the banks of Newfoundland, when a period of comparatively equable stability intervenes until the superincumbent pressure has been renewed. Is not the same process, perhaps on a much larger scale, because on a less interrupted area, going on in our Southern Ocean? Ross' ice-barrier has been proved to be a 'floating mass,' at least five times as great below as above sea-level; its recession does not mean that it recedes, but that by pressure or possibly by volcanic action, vast masses are cut away and floated northwards by the prevailing south wind, and the edge that is left remains further back by thirty miles to what it was sixty years ago. Is this a permanent 'set back' or will the gigantic ice-cap behind, renewed by successive deposits of snow, reassert its pressure, and again drive its ice barrier to the position or even further north which it occupied in 1841-3?[1]

But while we know that this vast withdrawal or 'recession' of the 'Ross Ice Barrier' has occurred since 1841-3, we are entirely ignorant, for lack of continuous accurate measurements, whether it may have taken place, equably, throughout the period of about sixty years, or have been the result of spasmodic efforts of pressure or volcanic agency, confined to within one or more minor portions of that period. Herein is where during almost two generations we have neglected our opportunities, and now find ourselves only on the threshold of a scientific research, in which we should have already accumulated so many valuable data.

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[1] "At the South Pole lies a continent surrounded by a great ring of water; gigantic masses of tabular ice come from the continent and slowly melt. Here is a great problem with reference to the difference between the North and South Poles."—Baron von Richthofen.

"The ice-barrier probably 1,600 feet in perpendicular height, of which 150 to 200 feet are above the sea."—Sir Clements Markham, Geog. Journ. November, 1899.

Capt. Scott is inclined to reduce this estimate to 1000 or 1200 feet; much would depend on the amount of earthy or saline particles in different bergs, affecting their specific gravity.

At the present stage of our enquiries it appears to me that one of the most important is, as to whether the Great Southern ice barrier consists of 'Palæocrystic ice,' *i.e.*, remains from some long distant Glacial Period, or of 'Recent Ice,' *i.e.* in constant formation varying in quantity as the deposition of snow varies from time to time, in cycles of yet unknown period.

The removal from the Ross Ice Barrier of such an almost inconceivable mass of ice as one 30 miles from north to south, and of unknown width, (but the barrier was originally estimated by Ross as 400 miles from east to west), and of probably 1,400 to 1,600 feet in thickness, and if of Palæocrystic formation, not to be renewed under the present conditions of our globe, is very startling, and tends towards Professor Richthofen's rather ominous hints of '*a* (temporary) *general drying up.*'

But this vast change in the 'Ross Ice Barrier,' almost due south of our shores or rather of New Zealand, does not perhaps, more immediately affect them; borne northwards to the Antarctic Circle, by the prevailing south winds, the drift meets the easterly current due to prevailing west winds of the Great Southern Ocean, and is carried towards the American continent, as plainly shown on our diagram. Referring to Sir Clements Markham's valuable paper in Geographical Journal of July, 1901, dividing the Antarctic regions into four quadrants :—

No. 1 Victoria Quadrant from 90° E. to 180° W.
,, 2 Ross Quadrant from 180° E. to 90° W.
,, 3 Weddell Quadrant from 90° W. to 0° E.
,, 4 Enderby Quadrant from 0° W. to 90° E.

the changes in the Ross Quadrant seem to expend their principal energies far away from our continent, and I am inclined to think that, from the selfish point of view, we should direct our main attention to the more accessible

coastal limits of the Victoria Quadrant, and part of the Enderby Quadrant; it is from these that the easterly drift bears the detached ice towards our shores.

Is there an equal, though at present less known, supply of material in those directions? About midway in the former, Bellamy, in 1839, discovered 'Sabrina Land,' a lofty mountain range covered with snow, Long. 122° E., and the Bellamy islands in Long. 165° E. Between these points Dumont d'Urville in 1840, January 20 (not three weeks out from Hobart) discovered Terra Adélie, Long. 140° E., "lofty land nearly hidden by icebergs."

January 21st, "Surrounded by icebergs, the Corvettes dwarfed by the surrounding masses, seemed to be in the narrow streets of a city of giants. . . sun shining in all its brightness."

January 27th to 30th further west he "discovered Côte Clarie, Long. 128° E., sailed along a vertical wall of ice, 100 to 150 feet high, for twelve hours, its aspects truly prodigious, could detect no land only an Ice Barrier, precipitous towards the sea. Reached the western extremity of this ice barrier trending S.W."

January 31st, "Ice barrier no longer in sight, but many ice islands. Shortly afterwards sighted barrier again to west and north-west, apparently a continuance of the former one and forming a great gulf around us, Lat. 65° 20′ S., Long. 128° 21′ E. Bore up for Hobart."

From the time of Dumont D'Urville (1840) we have gained little further information respecting these quadrants; they were visited by the 'Challenger' in 1874, and by the German Exploring Ship 'Valdivia' in 1898, neither of which much more than skirted the Antarctic Circle, but confirmed the existence of the Ice Barrier as far west as Long. 78° 22′ E. From indications based on the isotherm of 32°, it has been supposed that d'Urville's Terre Adélie and Côte Clarie are only large islands, and that any continental land is far to the south; in fact that there is a space of 250 to 300 miles

between those indications of land near the Antarctic Circle and Victoria Land.—(Sir Clements Markham, July 1901.)

The day must come when our Commonwealth Nation must recognize its duty in assisting scientific research, at least so far as it may intimately concern its own interests. I do not refer to extensive expeditions in search of the South Pole, or the solution of general scientific problems, but of comparatively trifling expeditions from time to time of a few weeks duration, to enable scientists and others to make such records as I have referred to, for the promotion of future knowledge as to the primary causes affecting our Australian climate.

I have far exceeded the limits I had proposed to my pen on this subject, but I hope that the points which have been brought before you, selected from a large amount of accumulated data, will have been of some interest to you. We must all take the heartiest interest in the expedition about to leave New Zealand under Lieut. Shackelton, R.N., with our friend Professor David, but as it is bound for the Ross Quadrant, we cannot expect it, for reasons above given, to fulfil the hopes of the editor of the *Evening News*, to be informed "as to whether the conditions prevailing there will influence our weather during the following year." Deductions from observations to be therein made, as relating to phenomena which have occurred far away to the leeward of our meridian, can only, as I have endeavoured to explain, inferentially apply to what we may assume to be cognate phenomena taking place in 'our Antarctic Ocean' under similar influences. But we feel sure that the learned Professor, winds and weather permitting, will do valuable service to general science, in his geological researches and other scientific investigations, amongst them I hope, on the structure of palæocrystic and recent ice; in the other matter, one man on a short visit can but

be an atom where the collated evidence of observations for a century, centuries may be required.

ADDENDUM, 1st January, 1908.

Further Antarctic Exploration.

Mr. Du Faur has suggested, through the Tourist Bureau, and Messrs. Burns, Philp and Co., the possibility of organising a *Midsummer's Picnic Excursion* to the Antarctic Circle, at the latter end of December next, drawing attention to papers read by him before the Royal Geographical Society in 1891 and 1892, and before the Royal Society of New South Wales on 4th December last, showing the apparently little personal risk therein involved.

As the most favourable time for starting on such a cruise from Hobart would be about Christmas, returning within the first fortnight of January, 1909, he has pointed out—

1. That this would be the season when many young men could most conveniently afford an absence of three weeks from their business, and scientists from their studies.

2. That there would be time to ventilate the subject in Europe, which might induce some of our visitors to take part therein.

3. That possibly the Admiralty, and the Commonwealth Government, might be willing to arrange for one of the smaller vessels on the station to accompany, as a consort, such first expedition.

4. That the attractions to be put forward, apart from the questions of meteorological and general scientific interest, as fully discussed in the papers above referred to, would be little more than an appeal to the spirit of adventure, not yet extinct—the novelty (to those who have not visited North Cape and the Arctic Circle), of the first experience of daylight throughout the twenty four hours,

and of a glimpse of the "midnight sun," and of the glorious effects of the "Aurora Australis," possibly some sport in sealing, &c., photography of Antarctic land and ice, and the being the first to renavigate seas not visited for nearly seventy years.

Details of the extent to which the Antarctic Circle may be followed need not, as yet, be considered. Dumont d'Urville passed along about 250 miles of it, calms much impeding his progress (in sailing vessels); from his furthest to where it was touched by H.M.S. "Challenger" in 1874, is 50° of longitude, equal to about 1400 miles, practically unexplored; the early navigators, before Dumont d'Urville, being debarred from approaching, under sail, lands which they sighted from a distance.

Should this proposal evoke any interest in the necessary quarters, a future opportunity will be taken of publicly illustrating, from the log of the "Astrolabe" (Dumont d'Urville), the daily experiences and traverses of that navigator, in the Antarctic Ocean (between 16th and 31st January, 1840), after passing through the belt of westerly winds in the lower latitudes of the Great Southern Ocean, which appear to justify the assertion that, under steam and equally favorable conditions, it may be considered as a "*Picnic Excursion.*"

A COMPARISON OF THE RAINFALL OF SYDNEY AND MELBOURNE, 1876 – 1905.

By A. DUCKWORTH, F.R.E.S.

[With Plates XVII. - XVIII.]

[*Read before the Royal Society of N. S. Wales, December 4, 1907.*]

As regards the weather and rainfall of Australia is there not rather too great a tendency to theorise and to draw conclusions based upon the experiences of one's own State rather than to extend the field of observations to the whole of Australia? With this in mind I have in the following paper endeavoured to shew both in tabular form and by diagrams a comparison for the past thirty years of the rainfall of Melbourne and of Sydney, based upon the records of the Observatories of these cities. I select these cities as the greatest population centres of Australia; the population of Melbourne and suburbs being 526,000, and that of Sydney 539,000, thus accounting for 1,065,000 out of a total of 4,123,000 inhabitants of the Commonwealth. New Zealand, however, which is a separate Dominion, also affords a singularly interesting field of observation, inasmuch as its records are officially stated to contain almost no evidence of any lasting drought. But the rainfall statistics both of New South Wales and Victoria furnish evidence of very great divergency in the annual amount of their rainfall distribution. It is necessary to point out that the figures relating to both Melbourne and Sydney are applicable only to the immediate vicinity of those cities. To show this it may be mentioned that whilst the average rainfall of Melbourne is given as 24·92 inches, that of the adjacent district, comprising the Yarra River and the Dandenong Creek, shows an average of 35·91 inches during the past ten years (1896 – 1905), and that whilst Sydney has an average

precipitation of 47·36 inches, Parramatta adjacent, records one of 39·0 inches only. The following table will perhaps more clearly illustrate the varieties of coastal rainfall; the rainfall in the interior being generally on a reduced scale the further we recede from the coast line. The average annual rainfall over a term of years for the capital cities of Australia is given below:—

Perth ...	33·5 inches.	Hobart ...	22·9 inches.
Adelaide ...	21·0 „	Sydney ...	47·4 „
Melbourne ...	24·9 „	Brisbane...	50·4 „

and for fuller comparison it may be added, that of London is recorded as being 25·0 inches, and that of New York as being 43·0 inches. The appended tables 1 and 2 show the comparative rainfall of Melbourne and Sydney during thirty years. There is evident at the outset a serious disparity in results, and it may perhaps be concluded therefrom that the nearer we approach the Equator the greater on the average will the coastal rainfall prove to be. Now, plotting out the rainfall of Sydney for example, (*vide* Diagram 1) on crosslined paper, each square of which denotes an inch of rainfall, we see first that in the thirty years 1876 – 1905, the year 1888 was the driest and 1890 the wettest, the average rainfall over the whole period being 47·36 inches. As regards Melbourne, the year 1898 was the driest and the year 1887 was the wettest during the period under review. In Diagram 2 is shown the relative variations from the average rainfall, both of excess and of deficiency, for Sydney and Melbourne during the thirty years under consideration. The greater deviations from the average in the case of Sydney stand out clearly. We have of course to bear in mind at the outset the comparative efficiency of the rainfall—a deluge may result in comparatively less good than a much smaller quantity evenly distributed over a longer period. In this regard I have shown the tabulated number of days per annum on which rain has fallen. As

regards the number of days per annum on which rain fell, the average number over the thirty years is 161 for Sydney, and 127 for Melbourne, or 44·1 wet days per 100 days in Sydney, and 34·8 wet days per 100 days in Melbourne. The maximum number of wet days in Sydney was 208, in 1893, and 153 in Melbourne in 1887; the minimum for Sydney being 112 in 1882, and for Melbourne 102 in 1898 and 1902.

It would seem in this connection that we require a "weighted average" rainfall, by which means we could gauge the intensity of the rainfall in conjunction with its duration. Further there would seem to be some reason why we should depart from calendar year periods in our method of recording rainfall statistics, if, as has been the view of many people, it is desirable to furnish seasonal forecasts such as obtain in India. A fall of rain at close of, or beginning of, a year may upset two years' seasonal records. Obviously the reversed seasons of Australia do not correspond with the calendar year. As an old writer has said:—

> "The north winds scorch, but when the breeze is
> Full from the south, why then it freezes;
> Now of what place can such strange tales
> Be told with truth, but New South Wales?"

But regarding the official figures of Sydney and Melbourne as plotted out in Diagram 1, shewing annual rainfall, it will be seen that in 11 years in Sydney the quantity exceeded the average, whilst in 19 years it was deficient. In Melbourne the rainfall was in excess during 16 years and deficient in 13 years, and of the average amount in the remaining year. If we were to judge solely from the *amount* of the annual rainfall of Sydney, without reference to its periodical distribution and the intensity of its precipitation, both however, important factors, the rainfall of Sydney, as contrasted with that of Melbourne, does not

show any actual period of serious drought, being below the Melbourne average only in the exceptional year 1888.

If we define the term 'drought' as being the absence of rain over a lengthened period resulting in a serious deficiency of the year's downfall, the people of Sydney are comparatively in a very fortunate position. To illustrate this point I would say that the rainfall of Sydney during the present year up to date, despite the droughty conditions which existed from about June until the end of October, say roughly four months, has been no less than 28·9 inches as compared with 29·2 inches for a similar period of the previous year. In view of the Melbourne average fall of 24·9 inches, why should we speak of a "drought" in Sydney at all? It must be remembered, however, that about one-third of the year's rainfall may happen in the first half of the Australian season—July to December—the remaining two-thirds falling in the second half year—January to June—and a serious irregularity in Sydney during the earlier 'dry' season would not be fully compensated by an equal excess happening in the later 'wet' season. The divergencies in the rainfall of these two great cities are so striking as to tend to make one careful in formulating any conclusions based on the rainfall experience of either city taken alone. The conditions affecting rainfall are those governing the evaporation of moisture from the sea, modified by the duration and strength of the winds carrying the rain from over-sea, and by the temperature of the soil in the areas over which the potential rain clouds are carried. Sydney is a coastal centre, whilst Melbourne occupies an intermediate position somewhat less influenced by coastal conditions.

Professor Gregory, at whose hands so many of the scientific problems of Australia have received elucidative treatment, in his book published in 1904, "The Climate of

Australasia," refers to the fact that "the Australian weather records are not in a suitable condition for satisfactory treatment," and he urged the creation of a united meteorological service working on a uniform plan and publishing uniform records. From this view there will probably be little dissent, and the recent movement towards uniformity of procedure merits approval. It may seem probable that Australian meteorological conditions are of a simpler nature than those affecting Europe for instance, but to quote from the authority just named:—"The apparent fickleness and severity of our climatic changes introduce as large an element of gambling into our farming as there is in many reckless mining ventures." The demonstration of some species of periodicity in our weather is eminently desirable, but it may be asserted on the strength of the tables which accompany this paper that such periodicity, whether it may be due to a sun spot cycle, the moon's cycle, monsoonal changes, or to the number and movement of icebergs in the Southern Ocean, or to a combination of causes, does not appear to be clearly discernible. It seems to me that, as regards the influence of the Antarctic regions, it will be necessary to study the meteorological experience of South Africa and South America in conjunction with that of Australasia in order to obtain fruitful results and to gain "a key to the succession of good and bad seasons."

I would acknowledge my indebtedness to Mr. Baracchi of the Melbourne Observatory for some recent figures supplied relating to the rainfall of Melbourne.

RAINFALL OF SYDNEY.

OBSERVATORY RECORDS, 1876–1905.

	Year.	Inches.	Wet Days.	
	1876	45·69	156	
	1877	59·66	147	
	1878	49·77	139	
	1879	63·19	167	
	1880	29·51	142	
	1881	41·09	163	
	1882	42·28	132	min.
	1883	46·92	157	
	1884	44·04	139	
	1885	39·91	145	
	1886	39·43	152	
	1887	60·16	160	
min.	1888	23·01	132	
	1889	57·16	166	
max.	1890	51·42	164	
	1891	55·30	157	
	1892	69·25	169	
	1893	49·90	208	max.
	1894	38·22	188	
	1895	31·85	171	
	1896	42·40	152	
	1897	42·52	137	
	1898	42·97	149	
	1899	55·90	172	
	1900	66·54	170	
	1901	40·10	131	
	1902	43·07	176	
	1903	38·62	169	
	1904	45·93	155	
	1905	35·08	144	

RAINFALL OF MELBOURNE.

	Year.	Inches.	Wet Days.	
	[illegible]	[illegible]	[illegible]	
	[illegible]	[illegible]	[illegible]	
	[illegible]	[illegible]	[illegible]	
	[illegible]	[illegible]	[illegible]	
	[illegible]	[illegible]	[illegible]	
	[illegible]	[illegible]	[illegible]	
	[illegible]	[illegible]	[illegible]	
	[illegible]	[illegible]	[illegible]	
	[illegible]	[illegible]	[illegible]	
	[illegible]	[illegible]	[illegible]	
	[illegible]	[illegible]	[illegible]	
	[illegible]	[illegible]	[illegible]	max.
max.	[illegible]	[illegible]	[illegible]	
	[illegible]	[illegible]	[illegible]	
	[illegible]	[illegible]	[illegible]	
	[illegible]	[illegible]	[illegible]	
	[illegible]	[illegible]	[illegible]	
	[illegible]	[illegible]	[illegible]	
	[illegible]	[illegible]	[illegible]	
	[illegible]	[illegible]	[illegible]	
	[illegible]	[illegible]	[illegible]	
	[illegible]	[illegible]	[illegible]	
	[illegible]	[illegible]	[illegible]	min.
min.	[illegible]	[illegible]	[illegible]	
	[illegible]	[illegible]	[illegible]	
	[illegible]	[illegible]	[illegible]	
	[illegible]	[illegible]	[illegible]	min.
	[illegible]	[illegible]	[illegible]	
	[illegible]	[illegible]	[illegible]	
	[illegible]	[illegible]	[illegible]	

Australasia," refers to the fact that "the Australian weather records are not in a suitable condition for satisfactory treatment," and he urged the creation of a united meteorological service working on a uniform plan and publishing uniform records. From this view there will probably be little dissent, and the recent movement towards uniformity of procedure merits approval. It may seem probable that Australian meteorological conditions are of a simpler nature than those affecting Europe for instance, but to quote from the authority just named:—"The apparent fickleness and severity of our climatic changes introduce as large an element of gambling into our farming as there is in many reckless mining ventures." The demonstration of some species of periodicity in our weather is eminently desirable, but it may be asserted on the strength of the tables which accompany this paper that such periodicity, whether it may be due to a sun spot cycle, the moon's cycle, monsoonal changes, or to the number and movement of icebergs in the Southern Ocean, or to a combination of causes, does not appear to be clearly discernible. It seems to me that, as regards the influence of the Antarctic regions, it will be necessary to study the meteorological experience of South Africa and South America in conjunction with that of Australasia in order to obtain fruitful results and to gain "a key to the succession of good and bad seasons."

I would acknowledge my indebtedness to Mr. Baracchi of the Melbourne Observatory for some recent figures supplied relating to the rainfall of Melbourne.

RAINFALL OF SYDNEY. RAINFALL OF MELBOURNE.

Observatory Records, 1876 - 1905.

Year.	Inches.	Wet Days.	Year.	Inches.	Wet Days.
1876	45·69	156	1876	24·04	134
1877	59·66	147	1877	24·10	124
1878	49·77	129	1878	25·36	116
1879	63·19	167	1879	19·28	127
1880	29·51	142	1880	28·48	147
1881	41·09	163	1881	24·08	134
1882	42·28	112 min.	1882	22·39	131
1883	46·92	157	1883	23·71	130
1884	44·04	159	1884	25·85	128
1885	39·91	145	1885	26·94	123
1886	39·43	152	1886	24·00	128
1887	60·16	189	max. 1887	32·39	153 max.
min. 1888	23·01	132	1888	19·42	123
1889	57·16	186	1889	27·14	125
max. 1890	81·42	184	1890	24·24	140
1891	55·30	187	1891	26·73	126
1892	69·26	189	1892	24·96	124
1893	49·90	208 max.	1893	26·81	140
1894	38·22	188	1894	22·61	138
1895	31·85	171	1895	17·04	131
1896	42·40	152	1896	25·16	124
1897	42·52	137	1897	25·85	117
1898	42·97	149	min. 1898	15·61	102 min.
1899	55·90	172	1899	28·87	116
1900	66·54	170	1900	28·09	139
1901	40·10	151	1901	27·45	113
1902	43·07	176	1902	23·08	102 min.
1903	38·62	169	1903	28·43	130
1904	45·93	155	1904	29·72	128
1905	35·08	144	1905	25·64	129

THE AUSTRALIAN MELALEUCAS AND THEIR ESSENTIAL OILS, PART II.

By RICHARD T. BAKER, F.L.S., Curator, and HENRY G. SMITH, F.C.S., Assistant Curator, Technological Museum, Sydney.

[With Plates XIX. - XXIX.]

[*Read before the Royal Society of N. S. Wales, December 4, 1907.*]

(3). *Melaleuca uncinata*, R. Br., in Ait., Hort. Kew, ed. 2, IV, 414.

Botany.—(*a*) *Systematic.*—This is quite an interior species of the continent and extends from the western edge of the coastal table-land right across to Western Australia. This species has many points of resemblance to *M. nodosa*, but apart from its habitat, is more readily to be distinguished from that species by its terete leaves with their numerous and conspicuous oil glands. It is also a more slender shrub than *M. nodosa*. It is well described in Bentham's Flora Australiensis, Vol. III., p. 150, where also its synonomy is given. The material, however, examined by us shows perhaps a little more variation than mentioned by that author. For instance, some specimens from the interior of New South Wales and Hog Bay, Kangaroo Island, have the claw of the staminal column at least twice the length of the petals, which latter organs, not described by Bentham, are found to be scarious, ribbed, and measure about 2 mm. or the length of the calyx, also the specimens from the dry interior are invariably silky pubescent, those from nearer the coastal plateau being glabrous. The material upon which this research is based, was obtained from Wyalong, New South Wales.

(*b*) *Histological.*—The anatomical characters of the leaves of this species present many interesting features that may probably prove of value in the histology of this group of Myrtaceæ, both for taxonomic as well as phylogenic purposes. Of those species of the genus so far examined, this one possesses histological characteristics entirely its own, and which apart from morphological and chemical characters, are in our opinion almost sufficient even for specific distinction. The dozen or so figures submitted with this paper are typical of a large number of sections made of various magnifications.

The leaves when examined macroscopically are found to be irregularly and numerously marked with dark dots. These are the oil glands. It is the configuration of the leaves (terete) that gives the circular outline to the transverse sections. One of the reasons for taking up the histological side of the subject was to ascertain the disposition and other data concerning the oil glands, and also if possible to trace the origin of the chemical constituents.

The most important new features to be noted are (1) the conical cells of the epidermis, (2) the transfusion tissue of the stele, and (3) the endodermic cells in the leaf substance. These are explained in detail under the description of each figure.

Longitudinal Sections.—Fig. 1 is a longitudinal section with a 25 magnification cut clear of the stele or mid-rib. This illustration was selected for reproduction as it gives a good idea of the numerous glands irregularly distributed throughout the leaf tissue; whilst figure 2 shows the appearance of a section magnified 80 times, cut through the medullary bundle in the plane of the phloem. This picture more particularly emphasises the irregularity of distribution of the glands, for here, the three sectioned are all on one side without any collateral ones. The conical

epidermal cells adjacent to the palisade parenchyma form a conspicuous object below the cuticle: and under a 325 magnification, the dark long lines in the vascular bundle can easily be determined as spiral and annular vessels, the latter being nearer the centre; other vessels which are well brought out, are referred to when dealing fully with the transverse sections. Air cavities have missed the edge of the knife in this instance, but are shown to be fairly numerous on the right hand edge of figure 1.

Transverse Sections.—In the transverse sections some interesting details are to be recorded. The terete character of the leaf gives to them an almost circular shape in section. In Fig. 3, the photograph depicts a portion of the leaf containing no oil glands. The two rows of palisade parenchymatous cells are well defined, as well as the fibro-vascular stele subtended by two smaller collateral bundles in the middle plane of the picture, and the numerous dark endodermic cells surrounding the bundles, the whole not being much unlike a section of a deep sea cable in appearance. In this as in all other sections the phloem is convex to the lower surface of the leaf.

Fig. 4 has twice the magnification (160) of Fig. 3; this is taken from the upper left hand portion of that section, and is reproduced to show the two stomata with guard cells at the top of the epidermic curve, these not being discernible in the previous picture.

Fig. 5 (magnified 80 times) one oil gland and part of another are seen in the top left hand portion of the section. These glands are of value here as they demonstrate the gradual displacement of the various vessels in the evolution of the gland, thus proving that in this species these bodies are of lysigenous origin. This displacement is further illustrated in photographs 6, 7, and 8, and what is also worthy of notice is the gradual diminution of endodermic

cells surrounding the pericycle of the stele as the number of glands increase in these sections.

In Fig. 8, these endodermic cells, whilst forming a feature of the picture, yet are comparatively few in number compared to those of figure 3. This varying number and irregular distribution of oil glands as shown in the various sections proves that these organs are true spherical bodies and not canals or ducts.

Fig. 9 is an enlargement showing the gland in the lower right hand corner of the previous figure. It gives the detail clearly and more particularly of (1) the conical cells of the epidermis: (2) a broken wall cell of the wall of lysigenous oil gland; whilst one of the smaller vascular bundles appears to be quite compressed between the two oil glands. The shape of the lower epidermal cells is quite unique, and none of similar character appear to have been previously recorded.

Fig. 11, magnified 160. This photograph is reproduced to show the intermixing of the spongy parenchymatous cells with those of the endodermis. A collateral fibro-vascular bundle is well brought out on the right.

Fig. 12, is a 160 magnification of a central portion of a section in which were found two cavities or lysigenous intercellular spaces near the centre or amongst the protoxylem. The presence of a few spongy parenchymatous cells can be traced between the endodermic cells and the palisade parenchyma.

Fig. 13 is a 210 magnification of the central fibro-vascular bundle of Fig. 7, showing the well marked endodermic cells which form a continuous border, whilst a few are to be seen scattered amongst the internal structure and several amongst the protoxylem cells. From these latter, radiate in rows the tracheids of the xylem alternating with those

of parenchyma; the former are the lighter coloured vessels, and the latter the darker ones which become paler as they approach the phloem. In a longitudinal section, spiral and annular vessels occur in this portion of the vascular bundle, the xylem being developed centripetally. The phloem borders the xylem in some thickness with many radiating or medullary rays, and concentric bands of vessels. The ventral (protoxylem) and dorsal (phloem) sides of the fan or wedge shaped portion of the stele are subtended by the pericycle, a homogeneous mass composed of thickened cells which may be regarded as transfusion tissue, and in view of the usual shape of tracheids of the xylem we can hardly hesitate perhaps to class them as such, which bodies appear to be the *sine qua non* of this substance. The structure of the cells favours then the statement by Scheit,[1] that its origin lies in the xylem and is homologous with that substance, although the phloem in its outer edges touches in this instance the endodermic circle and so bars access to the xylem to those cells in juxtaposition to the phloem.

Fig. 14 is a section cut longitudinally through the phloem and xylem and shows the vessels of this transfusion tissue in their long axis, their resemblance to the tracheids of the xylem contiguous with the cambium, is in accord with Scheit's theory as to their origin.

Chemistry.—The yield of oil obtained from this species by distillation on commercial lines, was 1·246%, 943 lbs. of leaves and terminal branchlets giving 188 ounces of oil. The material was collected in the month of March, at Wyalong, New South Wales. The crude oil was but slightly coloured, being yellowish in tint. It had a strong cajuput odour, with but a slight indication of the presence of volatile aldehydes; in this respect it was different from the

[1] Indische Zeitschr. f. Naturwiss., Band xiv., 1883.

oil of *M. nodosa*. The specific gravity was somewhat high, and the crude oil would answer to the general tests for oil of cajuput, as given in the British Pharmacopœia. The oil contained most markedly a crystalline substance, particularly in the portion coming over late in the distillation. The oil of this species is rich in cineol, and the presence of a small amount of dextro-rotatory pinene was determined by the rectification of the lower boiling portions. Phellandrene does not occur. The oil contains a considerable amount of constituents boiling at high temperature, as indicated by the high specific gravity of the oil. Besides the crystalline substance, a sesquiterpene was present, and the reactions with this constituent were similar to those obtained with the corresponding substance in Eucalyptus oils. The amount of esters in the crude oil is small, the saponification number being only 3·05. The crude oil was soluble in 1½ volumes of 70% alcohol (by weight) and afterwards soluble in all proportions. The optical activity was to the right; this was due to the presence of the pinene and to the crystalline substance, both of which were dextro-rotatory.

To determine approximately the rate of distillation of the principal constituents in the leaf, the oil from one of the distillations was collected at the end of each hour, and the oil belonging to that hour determined separately. The distillation was continued for four hours. The oil which came over during the first hour contained the largest proportion of the cineol, the second hour oil contained somewhat less of that constituent, the third hour oil only contained about 15 – 20% of cineol, while that distilling during the fourth hour hardly contained any. The amount of material used was 216 lbs. During the first hour 16 ounces of oil were obtained, or 0·463%; the second hour also gave 16 ounces; during the third hour 6 ounces distilled,

or 0·173%, and during the fourth hour 2½ ounces, or 0·0724%. The results given by each hour oil were as follows:—

	Specific gravity at 21° C.	Refractive index, same temperature.	Rotation 100 mm tube.
First hour oil ...	0·9139	1·4665	a_D + 3·9°
Second hour oil...	0·9139	1·4733	a_D + 7·6°
Third hour oil ...	0·9223	1·4815	a_D + 11·4°
Fourth hour oil...	0·9335	1·4900	a_D + 15·4°

The oils obtained during the first and second hours resemble each other somewhat closely. It will also be seen that the dextro-rotation increased considerably in the fourth hour oil. This was mostly due to the presence of the crystallised body. The saponification number for esters in the fourth hour oil was 5·1. A portion of this oil was esterised in the usual way, when the saponification number had increased to 34·08, so that 28·98 was due to the alcohols present in the fourth hour oil, or equal to 8·21% free alcohol, calculated as $C_{10}H_{18}O$.

Another distillation was continued for five hours so that the whole oil in the leaf might be obtained; this equalled 1·307%; it had specific gravity 0·9211 at 21° C., refractive index 1·476 at 21° C., and rotation a_D + 7·5°.

The results obtained with the mixed crude oils of the several distillations, and which may be taken as representing the average oil of from four to five hours distillation, were as follows: specific gravity at 15° C. 0·9259; rotation a_D + 7·2°; refractive index at 15° C. = 1·4788.

On rectification only 4% distilled below 172° C. (cor.) Between 172–177° C. 41·6% distilled. This fraction had specific gravity 0·9086 at 15° C.; rotation a_D + 5·1°; and refractive index 1·4695 at 17° C. Between 177–195° C. 24·8% distilled. This had specific gravity 0·9153; rotation a_D + 2·3°; and refractive index 1·4706; no indication of an active limonene is thus shown. Between 195–197° C. 2·6%

distilled. This had specific gravity 0·9186; rotation $\alpha_D + 2·1$; refractive index 1·4738. The remainder, consisting of high boiling constituents was 27%; this was transferred to a vessel and allowed to crystallise. After some days a thick pasty mass had formed; this was spread on porous plates and a whitish crystalline mass obtained after absorption was complete.

The oil distilling below 195° C. was almost colourless, and the odour strongly resembled that given by the richer Eucalyptol oils obtained from certain of the Eucalypts. The specific gravity was 0·9128 at 15° C.; refractive index 1·4689; rotation $\alpha_D + 3·7°$; cineol 66% by the phosphoric acid method. The colour reaction with phosphoric acid was most marked, due to the large amount of high boiling constituents present in the crude oil, and the mixture became reddish in colour long before the combination with the phosphoric acid was complete. On again redistilling 200 cc. of this oil, nearly the whole distilled below 180° C. The first 9 cc., boiling 156 – 158° C., had a rotation + 12·3 and gave a nitrosochloride melting at 103° C. It was evidently pinene.

It is apparent that if "cajuput" is required, then the leaves should be distilled from four to five hours: if only the cineol (eucalyptol) portion is desired, then the distillation need only be continued for about two hours. It must be remembered, however, that numerous species of Eucalyptus are now known which give an abundance of oil exceedingly rich in eucalyptol, so that the possibility of preparing the lighter portion of the oil of *M. uncinata* commercially is doubtful. Success in this direction seems to be possible only by preparing the oil as "cajuput." Copper fittings were not present in the apparatus used for distilling the oil, so that the green colour, which is usually due to copper, was absent.

The small amount of pinene present was dextro-rotatory, and so differs from the lævo-rotatory form found in most kinds of ordinary "cajuput." The oil does not, therefore, meet the demands for rotation in the American Pharmacopœia. This constant, however, is of minor importance, and is omitted in the British Pharmacopœia. The somewhat high dextro-rotation of the crude oil (+7·2°) is mostly due to the stearoptene, which constituent influences the rotation more than does the pinene.

Schimmel & Co.,[1] give the following results, obtained with the oil of this species, sent to them from Adelaide, South Australia, in 1892. Specific gravity 0·925. Optical rotation + 1° 40′. Mostly distilled between 175° and 180°C. Rich in cineol. The highest boiling portion probably consists of terpineol. No information as to yield of oil is given.

In the *Technologist* for 1863, p. 28, it is recorded that an oil was obtained from plants, stated to be this species, from the Botanic Gardens, Melbourne. The material was collected in November. The specific gravity of the oil was 0·920. Only 1·75 ounces of oil was obtained from 100 pounds of fresh leaves and branchlets. This is a remarkably small yield, particularly as the leaves of *M. uncinata* contain numerous oil glands. The yield we have obtained is more than ten times as great.

The Solid Alcohol.—The whitish crystalline mass, obtained as previously stated, was dissolved in a considerable amount of alcohol, and water slowly added until the oily portion separated. After standing, this was filtered off and allowed to crystallise, when is was again spread on porous plates as before. The filtrate was poured into a large quantity of water and allowed to crystallise. The crystals soon formed, interlacing each other in needles, producing a white bulky mass. This was filtered off and spread

[1] The Volatile Oils, p. 523.

on porous plates to dry. When the oil had been absorbed from the first precipitate, it was again treated in the same way. By repeating the process several times the oily portion was eventually entirely removed. The material thus obtained was recrystallised repeatedly from alcohol, from acetone, and finally from petroleum ether. A product of constant melting point was thus obtained. Unfortunately a considerable amount of the crystalline substance had been lost by the continued absorptions. After the final purification from petroleum ether, the substance was snow-white and granular in appearance. The odour was but slight, somewhat indefinite, and with no indication of a hyacinth-like odour. The melting point was 72·5° C. This was best taken by the open capillary tube method. A portion was melted at the lowest possible temperature and then drawn into the tubes. It remained twenty-four hours to completely crystallise, and 6 mm. of the column was retained. The heating was in water, and the melting point taken at the instant when the substance commenced to rise in the tube. The specific rotation was determined in absolute alcohol at 20° C., using sodium light, it was $[a]_D + 36·99°$. The percentage of active substance was 11·003.

It sublimed somewhat readily in acicular crystals, and was unaltered, the sublimate melting at the same temperature as the original substance. When melted, it had a tendency to remain for some time in a state of superfusion; the crystallisation then took place in circular radiating masses which continued to grow until the whole was crystallised. It was readily soluble in acetic acid, chloroform, carbon tetrachloride, alcohol, ether, acetic ether, acetone and organic solvents generally, crystallising again in radiating rosettes when the solvent had evaporated.

The formula is $C_{10}H_{18}O$ derived from the following determinations:—

0·1474 gram gave 0·422 CO_2 and 0·153 H_2O.
$C = 78·08$; $H = 11·54$.
0·1422 gram gave 0·4057 CO_2 and 0·147 H_2O
$C = 77·81$; $H = 11·5$.
$C_{10}H_{18}O$ requires $C = 77·92$; $H = 11·68$ per cent.

It is known that ordinary "Cajuput" oil contains a solid inactive terpineol, first isolated by Voiry in his investigation of oil of cajuput.[1] The semi-annual report of Schimmel and Co., April, 1901, contains a later research on terpineol in which the constants for that substance isolated from cajuput oil were determined. It is there shown that the solid inactive terpineol of cajuput oil melts at 35 – 36° C., which is the general melting point of crystallised terpineol. Dextro-rotatory solid terpineol occurs in Lovage oil (*Levisticum officinale*) and the slightly lævo modification in Niaouli oil (*Melaleuca viridiflora*).[2] A solid alcohol obtained from Melaleuca oils, resembling terpineol in some respects, but having a melting point 72·5° C. has not previously been isolated. The crystalline stearoptene occurring in the oil of *Melaleuca uncinata*, differs, therefore, from that of ordinary cajuput oil in being somewhat highly dextro-rotatory, and in having a melting point as high again as the solid terpineol found in ordinary cajuput oil.

Baeyer has succeeded in preparing from tribromoterpane, a solid terpineol, melting at 69 – 70°, but so far this does not appear to have been found occurring naturally. If on further investigation the crystalline substance isolated from the oil of *Melaleuca uncinata* is found to be new to science, as appears probable, the name *Uncineol* is proposed for it.

When more species of this genus shall have been investigated, we hope to be able to demonstrate a close relationship between the structure of the leaf and the oil con-

[1] Compt. rend., 106, p. 1538. [2] Compt. rend., 116, p. 1072.

stituents, similar to that existing between the venation of the leaf and the oil constituents of the Eucalypts.

(1). *Melaleuca nodosa*, Sm., in Trans. Linn. Soc. III, 276, and Exot. Bot. t. 35:

Botany.—(*a*) *Systematic.*—A fairly tall shrub, mostly found growing in dense masses rather than in individual trees, and generally known as "Tea Tree Scrub." The leaves vary in shape and length ranging in the former case from flat to almost terete, and measuring from half to nearly two inches in length; are rigid and pungent pointed. The flowers and fruits are well described in Bentham's Flora Australiensis, Vol. III., p. 158, where also will be found a list of the species synonymy. Its geographical range extends from the Blue Mountains to the Queensland border, and it may therefore be regarded as a coastal species.

(*b*) *Histological.*—A transverse section of the leaves gives quite an oval figure as shown in the illustrations, and there appears little to indicate either the upper or lower surface of the leaf except the orientation of the phloem and xylem of the central vascular bundle (midrib), or the shorter longitudinal axis of the parenchyma cells. The convex side of the phloem faces the lower surface of the leaves. Stomata are not shown in any of the sections cut; the epidermic cells form quite a narrow uniform band around the parenchymatous cells of palisade layers. These latter consist of two well marked contiguous rows running uniformly round both surfaces, but slightly shorter in length on the lower one. This uniformity is, as far as our researches go in this direction of the Myrtaceous plants unusual, more numerous layers generally obtaining in the upper surface, although perhaps in this case a set off occurs in the longer parenchyma cells of the upper portion of the leaf. This comparative regularity of disposition of cells we would suggest, indicates an immunity or at least a common surface

protection from the sun's rays. And this idea is supported by the occurrence of the oil glands which are to be found irregularly distributed in either field of the palisade layers.

The palisade parenchyma surrounds or encloses a mass of mesophyll, in the centre and in each extremity of which is a vascular bundle, the largest one being in the centre, which is more highly developed than the others. These various features call for little further remark as they conform to the generally accepted conception of such vessels.

The central fibro-vascular bundle differs from that of *M. uncinata* described in this paper, in that it is not surrounded by endodermic cells separating it from the mesophyll and parenchymatous palisade vessels. As far as we have been able to ascertain, endodermic cells are wanting, the transfusion tissue extending even up to the palisade layers. The glands as in other species of Melaleuca examined, are found to occur irregularly throughout the leaf substance, this character being shown in Figs. 15 to 20, and these also prove that they are not oil ducts or canals but oil glands. They are also lysigenous. Fig. 21 and 22 are longitudinal sections of the leaf of different magnifications and confirm the remarks upon the various organs above described.

Chemistry.—The yield of oil obtained from the leaves with terminal branchlets of this plant was 0·664%, 419 lbs. of material giving 44½ ounces of oil. The material was collected at Belmore, near Sydney, in the middle of the month of June. The crude oil was reddish in colour, but this colour was accidental, it being due to distilling the leaves in iron vessels. The red colour was readily removed by agitating with dilute alkali or with a few drops of dilute phosphoric acid; the oil thus treated, when well washed and dried, was of a light lemon tint and was very mobile. It had a terpene-like odour, but this was somewhat masked

by the presence of a small amount of aldehydes, probably butaldehyde or valeraldehyde.

The specific gravity of the oil of this species is very low for a Melaleuca oil, and it contains much dextro-pinene. The presence of this terpene in quantity in the Melaleuca oils does not necessarily, therefore, indicate the sophistication of a Melaleuca oil with turpentine when it is of low specific gravity. Cineol was the other principal constituent present. The oil contained only a comparatively small amount of high boiling constituents, and 92% distilled below 183° C. The principal high boiling constituent was a sesquiterpene, which corresponded in its reactions to that occurring in the oil of certain Eucalypts. Only a small amount of esters was present. The crude oil had a low refractive index. It was insoluble in ten volumes of 70% alcohol by weight, but soluble in one volume 80%. The first fraction was also insoluble in ten volumes 70% alcohol. No crystalline constituent was detected in the oil of this species, nor does phellandrene occur in it.

The crude oil had a specific gravity 0·8984 at 15° C., a refractive index 1·4689 at 18° C., and a rotation in 100 mm. tube a_D +11·6°. On rectification 62% distilled between 158 – 172° C., (cor.). This fraction had specific gravity 0·8917; refractive index 1·4686; rotation a_D + 14°. Between 172 – 183° C., 28% distilled; this had specific gravity 0·9022; refractive index 1·4689; rotation a_D + 6·5°. Between 183 – 245° C. 5% distilled; this had specific gravity 0·9161; refractive index 1·4741. By the phosphoric acid method the crude oil contained 33% cineol; the second fraction contained 48% cineol. The saponification number for the esters was 7·24.

The first fraction was again distilled and the portion boiling between 155 – 160° C. collected apart. This was again distilled, and 11 cc. (representing 11% of the original

oil), was obtained, boiling between 155 – 157° C. This was water-white and had a pinene odour. It was found to still contain a small amount of cineol; this was mostly removed by shaking with a few drops of phosphoric acid. The uncombined portion was filtered off, washed and distilled. It had a specific gravity 0·869 at 15° C.; refractive index 1·4695 at 17° C., and rotation $a_D + 25{\cdot}2°$. Although still not quite pure, yet it was sufficiently so to show that a large portion of the oil of this species is dextro-pinene, and the nitrosochloride prepared from it in the usual way melted at 103° C. The cineol was separated from the phosphate and determined to be that substance.

The oil of this species thus consists principally of pinene and cineol. It is deficient in the required characters for "cajuput." The oil very closely resembles the eucalyptol-pinene oils obtained from certain species of Eucalyptus, which contain about 30 – 40% eucalyptol. It has therefore little commercial value, and cannot compete with Eucalyptus oils. Our acknowledgments are due to Mr. F. H. Taylor for his kindness in cutting the sections illustrated in this paper.

ABORIGINAL NAVIGATION AND OTHER NOTES.

By R. H. MATHEWS, L.S.

[*Read before the Royal Society of N.S. Wales, December 4, 1907.*]

IN this paper I have briefly touched upon the aboriginal methods of navigation, for the purpose of showing that practically the same kind of canoes and rafts is used throughout Australia, which is suggestive of the unity and common origin of the native race.

Canoes made from a single sheet of bark, generally stripped from a bent tree, were used by the natives of every part of Australia, with the exception of a portion of the coast of Western Australia from Eucla to Albany and onward about as far as Gladstone. One of my friends who has been acquainted with the country between Perth and Israelite Bay since 1844, states that he never knew or heard of either canoes or rafts being used by the natives between the points mentioned. Canoes were never seen among the natives of Tasmania, but rafts took their place. The rafts were made of two or more logs of buoyant wood lashed together with bark ropes or thongs of skin.

Rafts were also in use on the north-west coast of Western Australia, all the way from the mouth of the Gascoyne River along the seaboard to Cambridge Gulf, and on as far as Port Darwin. The rafts used in Tasmania were practically of the same construction as those made at Port Darwin and other parts of Australia. Canoes made of one sheet of bark were seen by Capt. P. P. King at Port Essington[1]—apparently just such a canoe as one might see

[1] 'Narrative of a Survey of the Intertropical Western Coast of Australia' (London 1827) Vol. I, p. 90.

on the Murray River in New South Wales or on the Gippsland lakes in Victoria. From Port Essington, which is one of the most northern points of the Australian continent, to the southern coast of Tasmania, comprises about thirty-three degrees of latitude. These facts show the wide geographic distribution and uniformity of our native navigation, whether by canoes or rafts.

With the exception of Tasmania and the portion of the coast of Western Australia above referred to, canoes were used in the same regions as the rafts. When a suitable sheet of bark was not obtainable for making a canoe, a raft was constructed in its stead. I have seen both canoes and rafts afloat at one time on the same large lagoon in New South Wales.

Capt. Watkin Tench says the natives of Sydney Harbour and Botany Bay paddled their canoes "several miles in the open sea."[1] Lieut. C. Jeffreys says the Tasmanian natives could "cross an arm of the sea or a lake in their rafts, which were made to skim along the surface of the water by means of paddles, with amazing rapidity and safety."[2]

Although the canoe is more serviceable for many purposes than the raft, yet the latter possesses the advantage that it is not so subject to damage by accident, or exposure to the sun. Bumping against a sharp rock or other obstruction may cause an injury to one of the logs or bundles of which it is made, without interfering seriously with the buoyancy of the rest of the raft. Such a mishap to a canoe might damage it beyond repair, or even cause it to sink. Perhaps this is the reason why rafts are so universally used.

It has been said by some writers that because the aborigines of Tasmania had no canoes, they must have reached that country before it was cut off from the main

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[1] 'Narrative of the Expedition to Botany Bay,' (London, 1789), p. 84.

[2] 'Van Dieman's Land,' (London, 1820) pp. 127-128.

land of Australia by Bass' Strait. I am of opinion, however, that it is quite possible that the Tasmanians crossed over in their rafts from island to island, long after the continuous land connection had been broken through by the sea. For a long period subsequent to the first severance of Tasmania from Victoria, there probably was a chain of islands extending from Wilson's Promontory viâ Kent's Group, Flinders and other islands to Cape Portland. There were no doubt other islands at moderate intervals, reaching across from Cape Otway viâ King island to Cape Grim, and at other places as well. All such islands, with the exception of those at present in existence, have disappeared either by subsidence or by the wearing action of the sea.

The hypothesis just stated appears to me more reasonable than the old theory that the Tasmanians travelled on dry land all the way from Victoria to their final home, because it brings us down to a much later geological epoch and agrees better with the time usually assigned to the advent of man. Moreover, from my investigations among the natives of South-east Victoria, as well as among those of the Great Australian Bight, I am disposed to think that there is not much difference between them and the defunct inhabitants of Tasmania, pointing to the conclusion that they have not been separated by a very great interval of time.

In certain northern portions of Australia, abutting on the shores of the Gulf of Carpentaria, the natives employed two or three or more pieces of bark in building a canoe, and it is noteworthy that such crafts are more elaborate in their manufacture than those in use in the southern parts of the continent, a fact which might suggest foreign influence, such as that of the Malays or Papuans at some comparatively recent period. Rafts and logs were like-

wise used on some of the rivers flowing into the Gulf of Carpentaria.

The "catamaran" and the "dug-out" canoe, now used by the aborigines of Cape York Peninsula, Port Darwin, and other northern parts of the continent, will not be included in this article, because I do not consider them of purely Australian origin, but believe them to be introductions from Torres Straits.

I would like to offer a few remarks on certain statements made by two of the early writers on the New South Wales aborigines. Dr. George Bennett, when travelling from Cullen Bullen to Dabee in the Rylstone district saw some kurrajong trees, upon which he makes the following comment:—"The wood of the kurrajong tree is used by the aborigines for boats and canoes."[1] Some years ago I was all through that district discharging my duties as a surveyor, and being aware of Dr. Bennett's statement, I made inquiry from old blackfellows if ever they had made canoes out of wood, but they had never heard of such a thing. I also asked white settlers of long standing in that part, and their replies were to the same effect. I am of opinion that Dr. Bennett was told by white people that the natives sometimes used dry logs of kurrajong and other light and buoyant woods as rafts, and that he did not differentiate between these and the actual canoe.

Mr. G. F. Angas says:—"Their canoes were very rude. To the southward and on the Murray River they are mere pieces of bark tied together at the ends and kept open by means of small bows of wood. Towards the north they have canoes of a more substantial character, formed of the trunks of trees, twelve or fourteen feet long; they are hollowed out by fire and afterwards trimmed into shape

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[1] 'Wanderings in New South Wales,' (London 1834) I., 115.

with the *mogo* or stone hatchet."[1] In 1860 I was working amongst stock on the Clarence and Nymboida, two important rivers in northern New South Wales, when the blacks were numerous and I saw them almost every day. I frequently crossed streams in bark canoes, but never heard of one cut out of a log of wood by the blacks. In several parts of New South Wales, however, I have seen canoes made by white men for crossing over rivers at sheep and cattle stations. A large, hollow tree was selected and cut down. The rotten interior was burnt out, and then cleaned more thoroughly with an axe. The ends were then blocked up with thin wooden slabs, securely nailed in position and afterwards caulked with rags or wool.

From the vagueness of the statements of both Dr. Bennett and Mr. Angas, I feel confident that they never saw log canoes (or "dug-outs") in use by the natives, but that they were misled by the careless reports of white men. It is of course possible that some of the aborigines occasionally copied the white man's method of constructing a canoe, after they had been supplied with iron tomahawks and axes, but I never heard of such a case.

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[1] 'Waugh's Australian Almanac for 1858' (Sydney) p. 56.

A SHORT VOLUMETRIC METHOD FOR THE ESTIMATION OF SULPHURIC ACID.

By THOMAS COOKSEY, Ph. D., B. Sc.

[*Read before the Royal Society of N. S. Wales, December 4, 1907.*]

THIS method depends upon the volumetric estimation of the excess of barium chloride left in solution after precipitation of the sulphuric acid as sulphate of baryta.

Estimation of Calcium and Barium by standard solution of Sodic Carbonate.—The metals of the calcium group can be directly estimated by a solution of sodium carbonate, provided no metals other than fixed alkalies are present. A method of estimating calcium has been described which consists of gradually adding the carbonate of soda to the hot solution until the pink colour given by phenol-phthalein remains permanent after boiling for a few minutes. This method is somewhat tedious and has the disadvantage of leaving a feeling of uncertainty as to the end point of the reaction. I have improved this process very considerably by making use of spirit of wine to cause the rapid precipitation of the carbonate of lime. The process is perhaps best carried out as follows:—The solution containing the calcium or barium salt free from carbonates, borates, phosphates, and silicates is made just neutral to phenol-phthalein with caustic potash. Standard sodic carbonate is now run in in the cold, and occasionally small amounts of spirit of wine or methylated spirit added with constant stirring until the proportion of spirit in the mixture at end of titration amounts to about one half of the whole. The carbonate of lime or baryta is then immediately thrown down and the end reaction with phenol-phthalein is sharp and distinct, more especially so in the case of barium. In dilute solutions

not containing sulphates this proportion of spirit can be added at first, and the titration carried out in the ordinary manner, when it will be found that a decinormal solution of sodic carbonate is equivalent to a similar one of either calcium or barium chloride, a correction being made for the acidity, found by the carbonate solution, of the total spirit used in the titration. It is, however, advisable to standardise the sodic carbonate against a standard barium chloride solution under the same conditions. I have not yet tried the reaction with strontium, but there is no reason why the method should not be similarly applicable to it.

Estimation of calcium.—10 cc. of a solution of calcium chloride containing ·1532% calcium required 7·65 cc., 7·6 cc., 7·7 cc. of $\frac{N}{10}$ sodic carbonate—mean 7·65 cc.

7·65 cc. are equivalent to ·01522 g. of calcium.

Estimation of barium.—10 cc. of a solution containing ·6868% of barium required 10·05 cc., 10·10 cc., 10·05 cc., and 10·10 cc.—mean 10·07 cc.—$\frac{N}{10}$ sodic carbonate

10·07 cc. are equivalent to ·06867 g. of barium.

In estimating calcium in presence of sulphuric acid one of the following methods may be adopted: either the spirit may be added gradually, so as not to precipitate the lime as sulphate: or having by a preliminary test carried out by means of a gradual addition of spirit found the approximate amount of sodic carbonate required, a slight excess can be run in, then the proper proportion of spirit added, and the true amount of sodic carbonate required found by titrating back with a dilute standard solution of hydrochloric acid

1 cc. of $\frac{N}{20}$ HCl being equivalent to 1 cc. $\frac{N}{10}$ Na_2CO_3

Estimation of Sulphuric Acid in a solution containing fixed alkalies only.—Any acidity of the solution is neutralised

by caustic soda, phenol-phthalein being used as indicator. There must of course be no carbonates, phosphates, silicates or borates present. A definite quantity of neutral standard barium chloride solution, more than sufficient to precipitate all the sulphuric acid as barium sulphate, is now added, and the proportion of spirit equal to half of the final total liquid, together with a few drops of phenol-phthalein. Then standard carbonate of soda is gradually run in with constant stirring until a permanent pink colour is obtained. The amount of barium chloride left in solution is given by the number of cc. of carbonate of soda run in. The difference between the latter figure and the amount of standard chloride added gives directly the SO_3 in original liquid.

Example.—5 cc. of a solution of Na_2SO_4 containing ·8989% SO_3 were taken. 15 cc. $\frac{N}{10}$ $BaCl_2$ added to the boiling test solution, the latter cooled and then after neutralisation, titrated with $\frac{N}{10}$ Na_2CO_3 with gradual addition of 25 cc. spirit of wine. 4·05 cc. $\frac{N}{10}$ Na_2CO_3 were required. 4·05 cc. − correction for spirit (·25) = 3·8 cc. 15 − 3·8 = 11·2 cc. $BaCl_2$ solution required for precipitating the sulphuric acid. This is equivalent to ·0445 SO_3 or ·890% SO_3.

In the estimation of sulphates in solution containing magnesium or other metals it is advisable to precipitate these by means of the mixture of hydrate and carbonate of potash and work upon the filtrate.

NEUTRALIZING ALKALINE SOIL.

1

2

Figs. 1 and 2, Show the action of nitric acid in correcting the injurious effects of alkali in the soil.

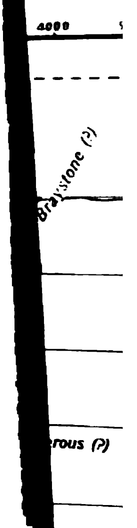
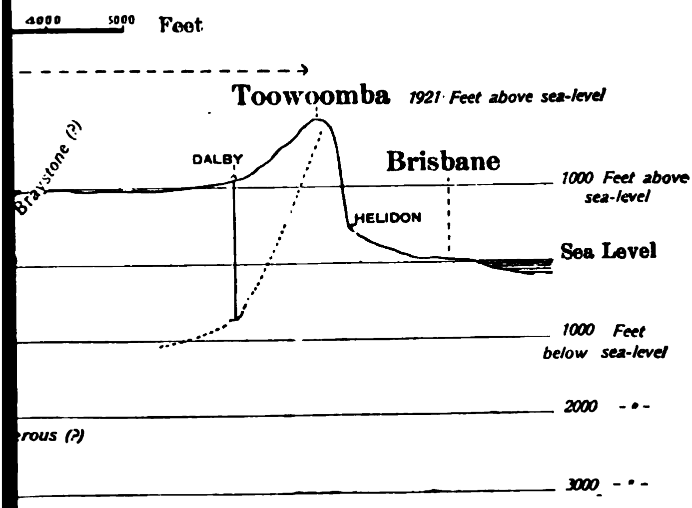

4000
Braystone (?)
rous (?)

Plate VIII.



4000
5000
Feet
Toowoomba
1921 Feet above sea-level
Braystone (?)
DALBY
Brisbane
1000 Feet above sea-level
HELIDON
Sea Level
1000 Feet below sea-level
2000 - " -
rous (?)
3000 - " -

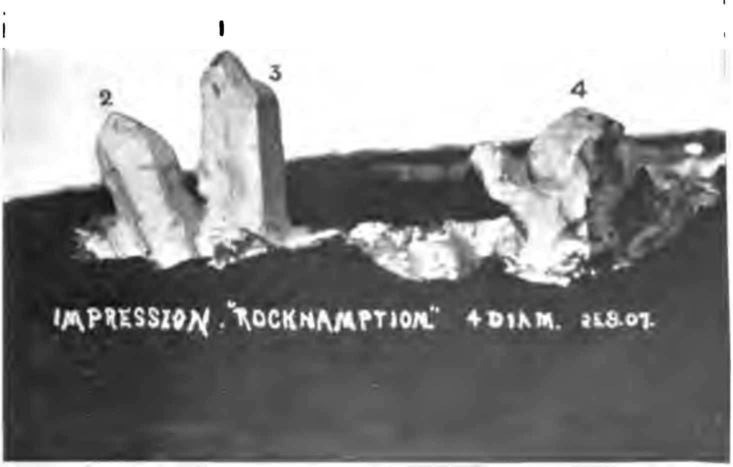
E. F. Pittman, Photo.

ARTESIAN WELL, YARRAWIN STATION, BREWARRINA DISTRICT.
Depth 1,472 feet. Yield 688,800 gallons per day.

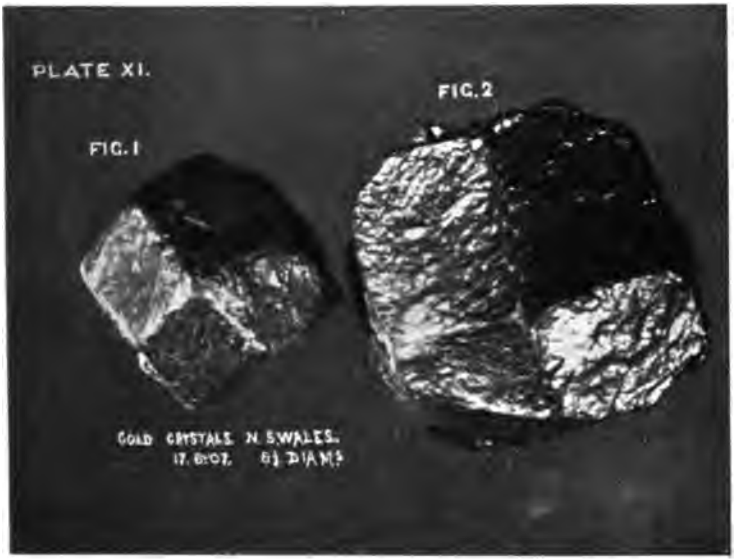
PLATE X. FIG.1.

Nugget from Rockhampton, enclosing quartz crystals. See arrows. Magnified 2 diameters.

FIG. 2.

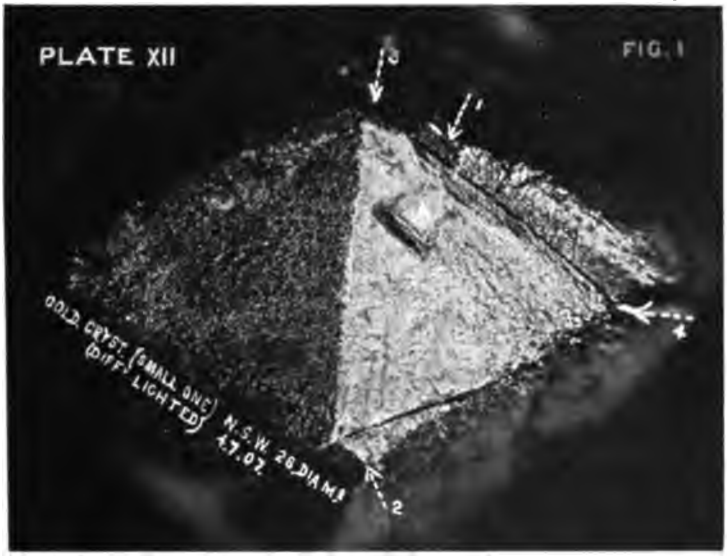


Casts of the cavities left after removing the quartz crystals. Enlarged 4 diameters.

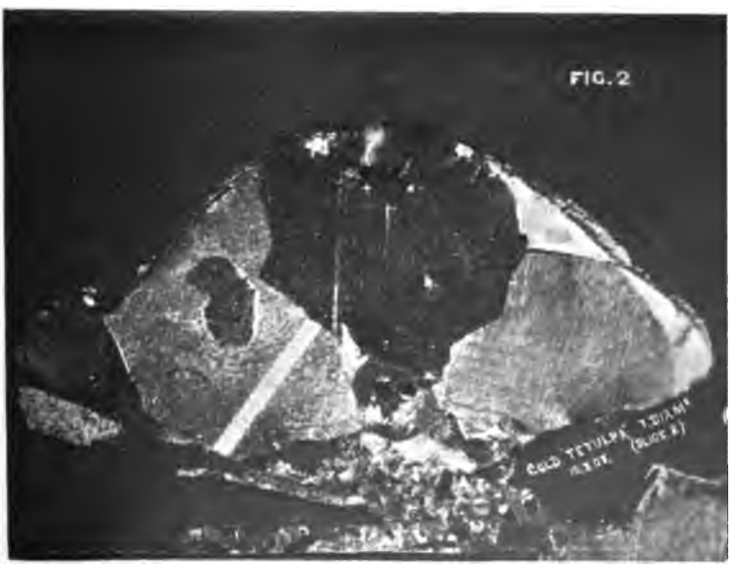


Gold crystals, New South Wales.
Enlarged 8 diameters.

The above crystals, Figs. 1 and 2, with their faces polished and etched. Enlarged 7½ diameters.



The right hand rhombic face of Fig. 3, Plate XI. Enlarged 18 diameters. Arrow No. 1 points to the secondary crystal A; Nos. 1, 2 and 4, to the dark line.



Section through two conjoined octohedral gold crystals, Tetulpa, South Australia. Enlarged 6½ diameters.

VOYAGE DE 'L'ASTROLABE,' DUMONT D'URVILLE—1840.

Reproduction of sketches taken near Antarctic Circle.

L. LE BRETON, Artist.

No. 1.—View of Ice Island, Lat. 64° S. 18th January 1840.

No. 2.—'Terre Adélie,' discovered 19th January, 1840.

VOYAGE DE 'L'ASTROLABE,' DUMONT D'URVILLE—1840.

Reproduction of sketches taken near Antarctic Circle.

L. Le Breton, Artist.

No. 3.—Ice Barrier off 'Terre Adélie,' 20th January, 1840.

No. 4.—Disembarcation on 'Terre Adélie.' 21st January, 1840.

VOYAGE DE 'L'ASTROLABE,' 1840.

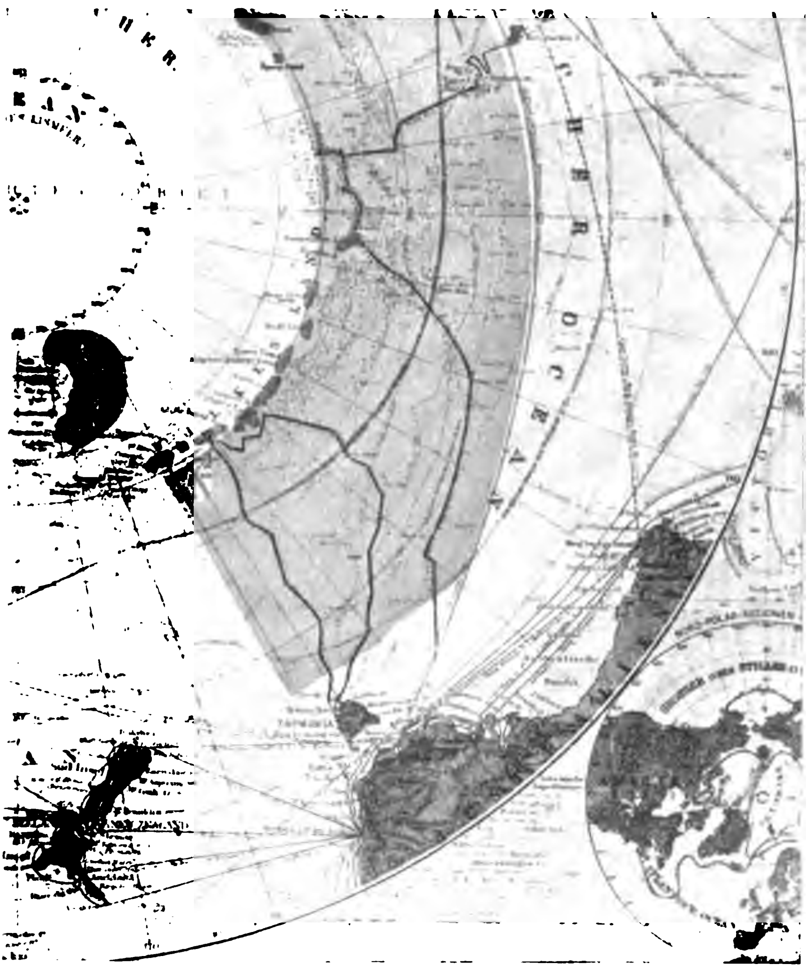
No. 5.—Taking possession of 'Terre Adélie,' 21st January, 1840.

No. 6. - A heavy squall amongst ice, 23rd January, 1840.

No. 7.—Discovery of 'Côte Clarie,' 26th January, 1840.

VOYAGE DE 'L'ASTROLABE,' DUMONT D'URVILLE, 1840.

Map showing the Victoria Quadrant of the Antarctic Circle, reduced from the 'Sud Polar Karte,' by Von A. Petermann.



Portion tinted blue shows an area of about 5½ million of square miles of the Great Southern Ocean, which has virtually never been traversed since Dumont d'Urville's voyage in 1840. (Partially visited by H.M.S. 'Challenger' in 1874.)

The tracks of the 'Astrolabe' and the 'Challenger,' and also of such vessels as pass south of Kerguelen's Land, are shown by firm dark lines.

Fig. 1 × 25

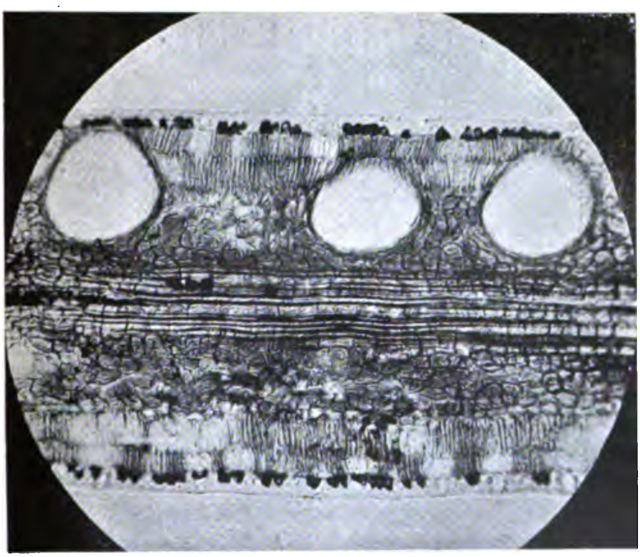


Fig. 2 × 80

Melaleuca uncinata, Sm.

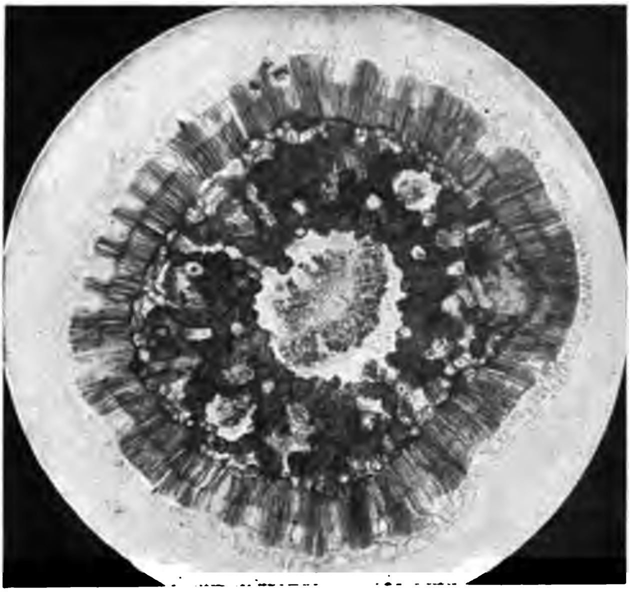


Fig. 3 × 80

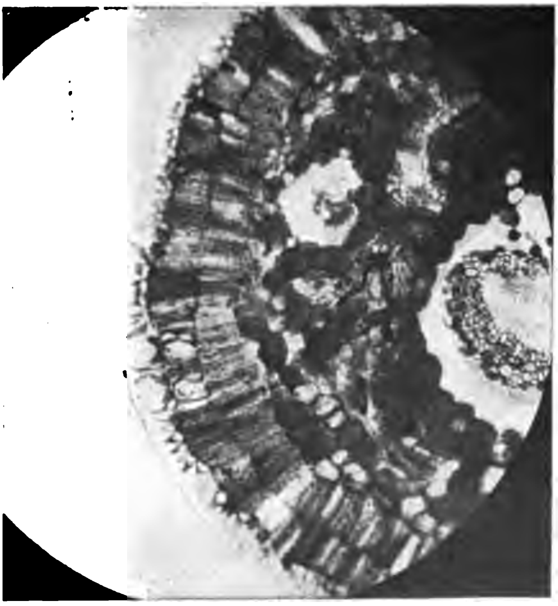


Fig. 4 × 160

Melaleuca uncinata, ***Sm.***

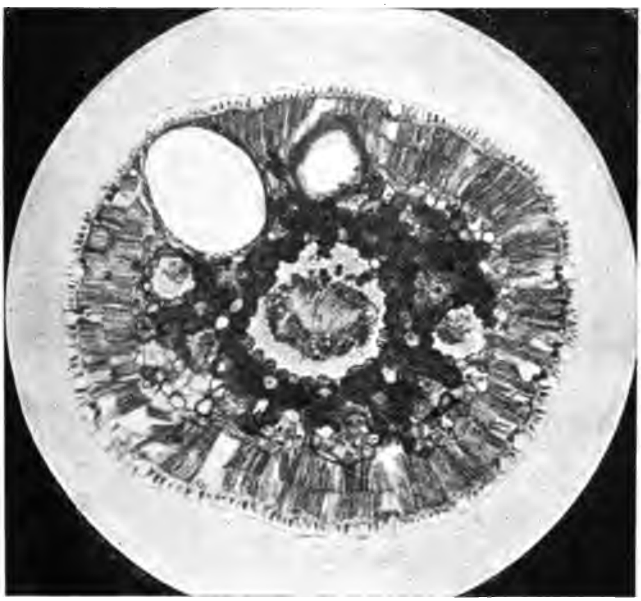


Fig. 5 × 80

Fig. 6 × 80

Melaleuca uncinata, *Sm.*

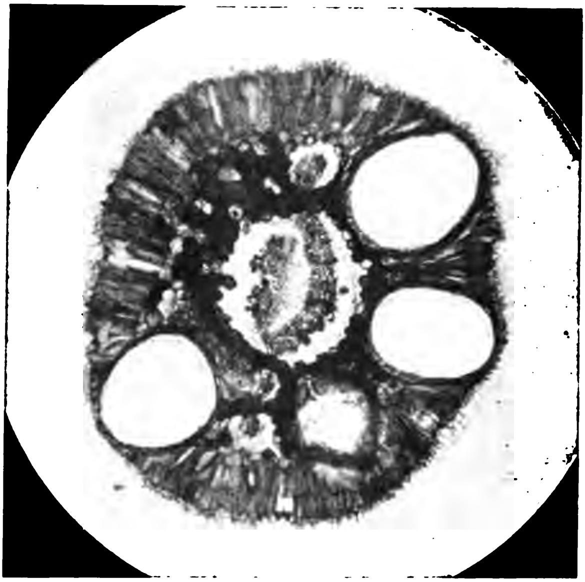


Fig. 7 × 80

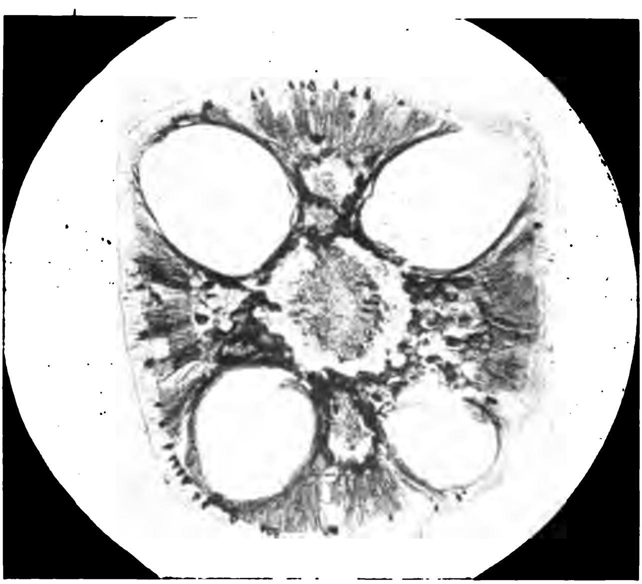


Fig 8 × 80

Melaleuca uncinata, *Sm.*

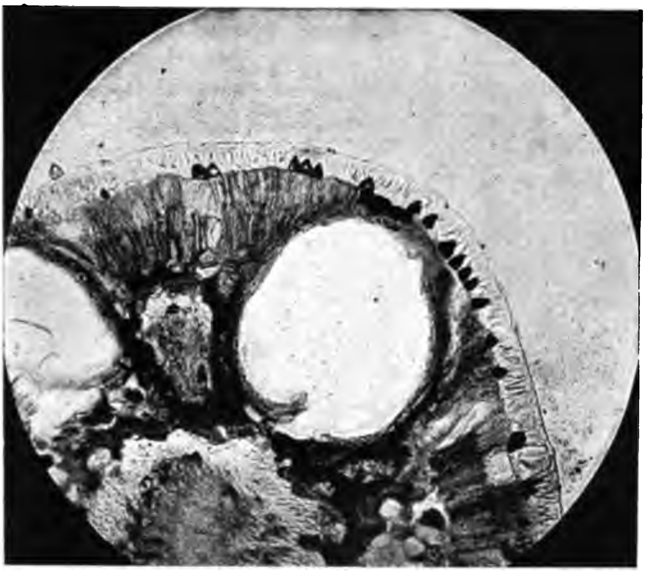


Fig. 9 × 160

Fig. 10 × 210

Melaleuca uncinata, ***Sm.***

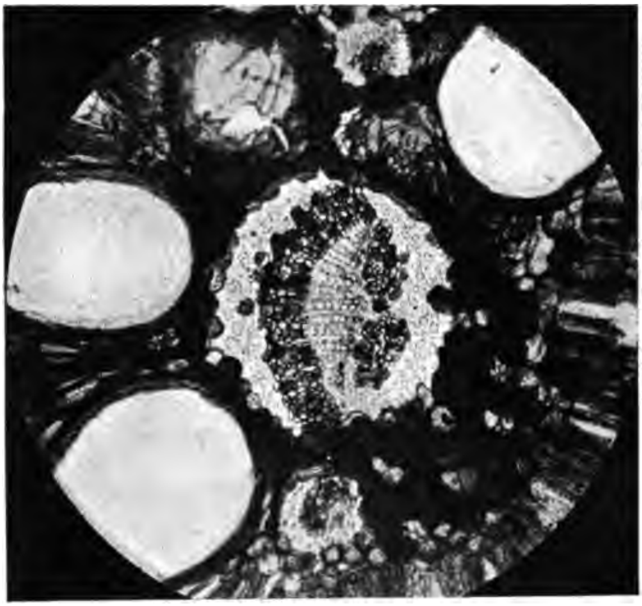


Fig. **11** × 160

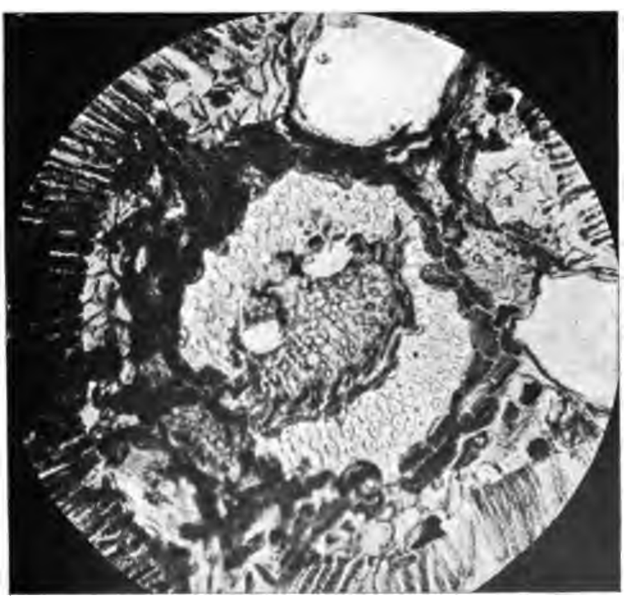


Fig. **12** × 160

Melaleuca uncinata, ***Sm.***

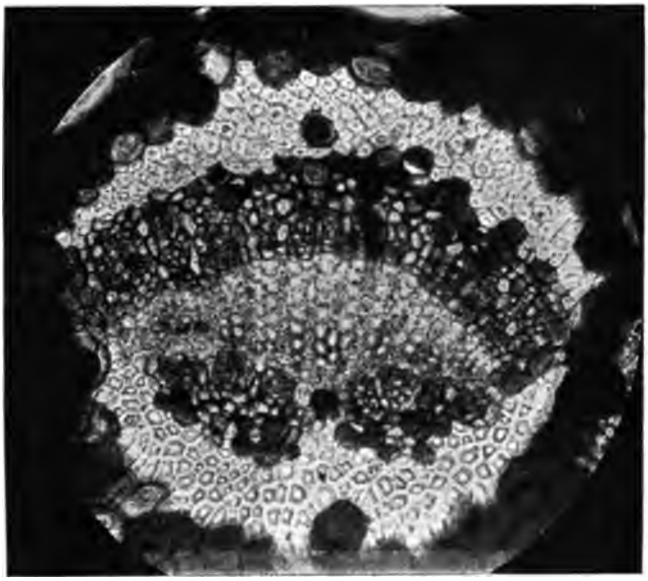


Fig. **13** × 320

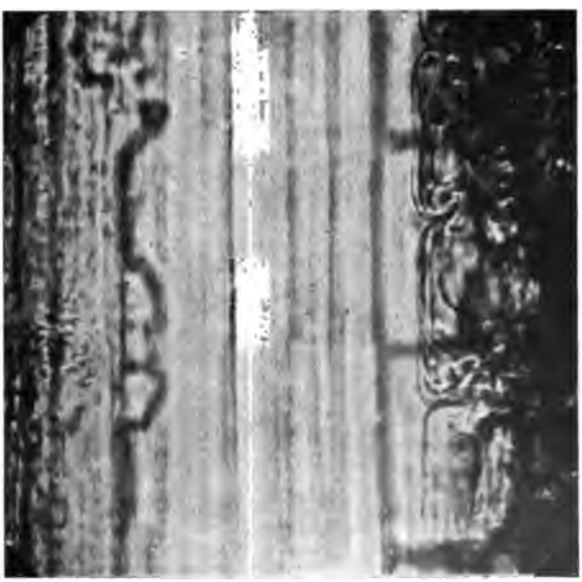


Fig. **14** × 500

Melaleuca uncinata, ***Sm.***

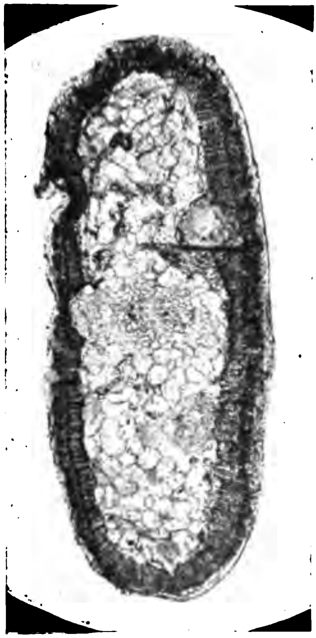


Fig. 15

Fig, 16

Melaleuca nodosa, ***Sm.*** **Both × 80.**

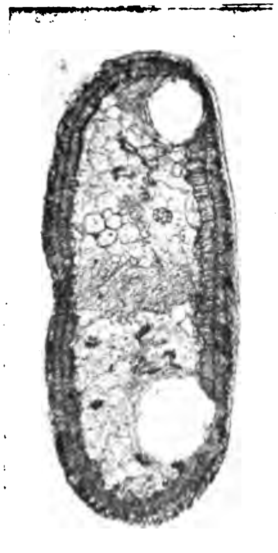


Fig. 17

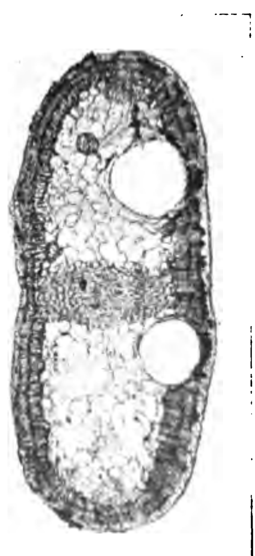


Fig. 18

Melaleuca nodosa, *Sm.* Both × 80

Fig 19

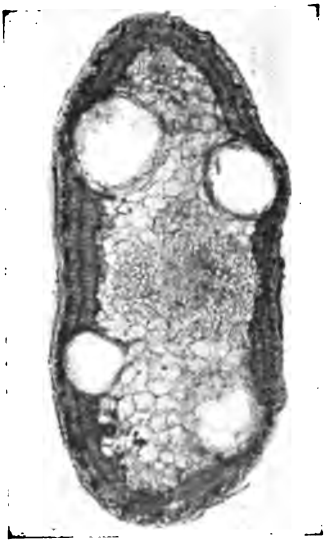


Fig. 20

Melaleuca nodosa, *Sm.* Both × 80.

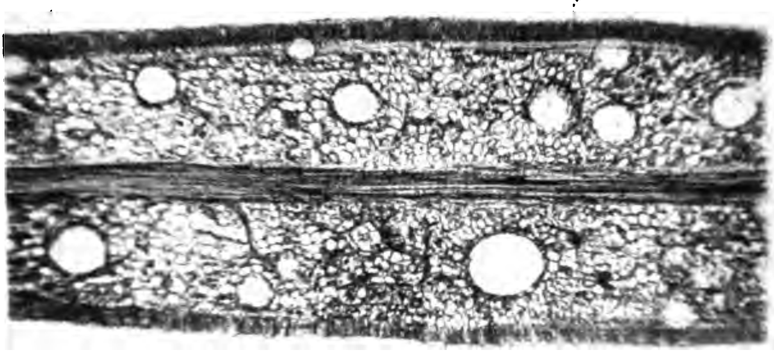


Fig. 21 × 80

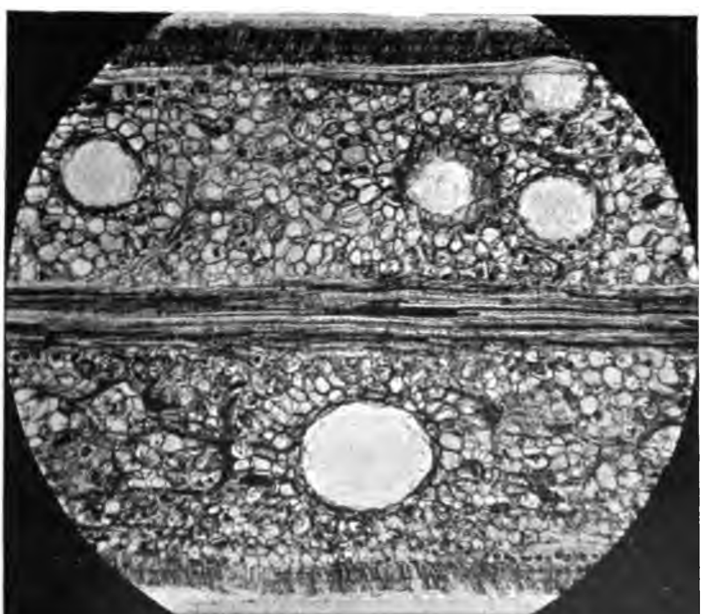


Fig. 22 × 160

Melaleuca nodosa, *Sm.*.

ABSTRACT OF PROCEEDINGS

—May 1, 1907.

ABSTRACT OF PROCEEDINGS

OF THE

Royal Society of New South Wales.

ABSTRACT OF PROCEEDINGS, MAY 1, 1907.

The General Monthly Meeting of the Society was held at the Society's House, No. 5 Elizabeth-street North, on Wednesday evening, May 1st, 1907.

Prof. T. P. ANDERSON STUART, M.D., LL.D., President, in the Chair.

Fifty-one members and two visitors were present.

Mr. C. HEDLEY and Mr. C. J. MERFIELD were appointed Scrutineers, and Mr. H. A. LENEHAN deputed to preside at the Ballot Box, but Mr. HEDLEY gave place to Mr. W. J. MACDONNELL at the Ballot for Officers and Members of Council.

The certificates of four candidates were read for the third time, of three for the second time, and of four for the first time.

The following gentlemen were duly elected ordinary members of the Society:—

HOSKINS, GEORGE HERBERT, Engineer, 'St. Cloud,' Burwood Road, Burwood.

WALEY, FREDERICK G., Assoc. M. Inst. C.E., Mine Manager, c/o Belambi CoalC o. Ltd., Bridge-street, Sydney.

WELCH, WILLIAM, Governor of New Zealand Institute, 'Roto-iti,' Boyle-street, Mosman.

WILSON, WILLIAM CLAUDE, C.E., Oxford-st., Epping.

A ballot was then taken and the following gentlemen were elected Officers and Members of Council for the current year:—

President:

HENRY DEANE, M.A., M. Inst. C.E.

Vice-Presidents:

Prof. T. P. ANDERSON STUART, M.D., LL.D.	F. H. QUAIFE, M.A., M.D.
H. A. LENEHAN, F.R.A.S.	T. W. E. DAVID, B.A., F.R.S.

Hon. Treasurer:

D. CARMENT, F.I.A., F.F.A.

Hon. Secretaries:

J. H. MAIDEN, F.L.S.	F. B. GUTHRIE, F.I.C., F.C.S.

Members of Council:

R. T. BAKER, F.L.S.	Prof. LIVERSIDGE, LL.D., F.R.S.
JOSEPH BROOKS, F.R.A.S., F.R.G.S.	HENRY G. SMITH, F.C.S.
A. DUCKWORTH, F.R.E.S.	WALTER SPENCER, M.D.
W. M. HAMLET, F.I.C., F.C.S.	H. D. WALSH, B.E., M. Inst. C.E.
T. H. HOUGHTON, M. Inst. C.E.	Prof. WARREN, M. Inst. C.E., Wh.Sc.

The following announcements were made:—

1. That the Society's Journal, Vol. XL., 1906, was in the hands of the binder, and would shortly be ready for delivery.

2. That the following series of Popular Science Lectures (with perhaps some modifications) would be delivered during the present session:—

May 16—"*The Life History of our Food Fishes,*" by H. C. DANNEVIG, (Superintendent, Fisheries Investigation).

June 20—"*Some Polynesian and Melanesian Groups and the People who live in them,*" by Rev. Dr. GEORGE BROWN.

July 18—"*The Bi-centenary of Linnæus' Birth,*" by J. H. MAIDEN, F.L.S.

August 15—"*Our Health Resorts,*" by T. STORIE DIXSON, M.B., C.M. (Edin.)

September 19—*Further Chapters in Early Australian History,* by F. M. BLADEN, F.R.G.S., F.R.H.S. (Lond.), Principal Librarian, Public Library.

October 17—"*Regeneration and Recent Biological Experiment,*" by Prof. J. T. WILSON, M.B. (Edin.)

Also a series of four Clarke Memorial Lectures was being arranged by Professor DAVID, if possible.

3. That the following alterations to the Rules passed at the General Monthly Meeting, December 5th, 1906, would

be submitted for confirmation this evening, it being the Annual General Meeting:—

i. By Prof. T. P. ANDERSON STUART, M.D., LL.D., that Rule VIII. be altered to read as follows:—"The certificates shall be read at the *two* ordinary General Meetings of the Society, etc., instead of *three*." Carried.

ii. By Mr. T. H. HOUGHTON, seconded by Mr. H. D. WALSH, that Library Rule V. be omitted. Carried.

iii. By Mr. R. H. MATHEWS, seconded by Mr. W. J. MACDONNELL, that Rule XXVI. be altered with the view to substituting March for May for the inaugural meeting of the Session. Not carried.

4. The President having referred with deep sympathy to the death of Mr. H. C. RUSSELL, the following resolutions moved by Mr. H. A. LENEHAN, seconded by Prof. LIVERSIDGE, and supported by Mr. G. D. HIRST, were carried:—

i. The Members of the Royal Society of New South Wales take this, the first opportunity to express their deep regret at the loss which the Society has sustained by the death, on February 22nd last, of their late Vice-President, and former President and Hon. Treasurer, Mr. HENRY CHAMBERLAIN RUSSELL, B.A., C.M.G., F.R.S., etc., Government Astronomer of N. S. Wales, and to place on record their full appreciation of his many and lifelong services in promoting the aims and objects of this Society and for the advancement of science in Australia.

ii. That the above resolution be forwarded to the late Mr. RUSSELL'S family, as an expression of the Society's deep sympathy with them in their bereavement.

Mr. RUSSELL was elected a member of the Society in 1864, a member of the Council in 1871, and he has practically been a member of the Council ever since. During

this time he has held office as Hon. Treasurer, as Vice-President, and as President for more than one period. Mr. RUSSELL read his first paper, entitled "Remarks on Tables for Calculating the Humidity of the Air," before the Society on December 8th, 1869, and contributed 69 papers in all; these are, of course, irrespective of numerous contributions to other societies, and of official papers and reports. Apart from the support he gave this Society by contributing the valuable papers referred to, he was always ready and willing to help in other ways, especially when there was a shortage of papers to read at our meetings; under such circumstances he would prepare some exhibit, experiments or note upon some scientific novelty, often at very short notice and at much inconvenience to himself. Not only did he freely give his time to this Society, but also to other institutions and societies, such as the University, the Board of Technical Education (of which he was Chairman for some years), and the Australasian Association for the Advancement of Science. His disposition was generous, kindly and sympathetic, and his wise, sound and experienced judgment was always at the disposal of this and kindred societies. His official work was of the greatest benefit to the public, the value of some of it is well known and appreciated, especially by pastoralists and the commanders of vessels. He was a most conscientious and devoted public servant; had he been less devoted to his work, and taken more relaxation from the very exacting duties of his position as Government Astronomer, he would probably have been with us still. By his death this Society and the Australasian Association for the Advancement of Science have lost one of their most capable, valuable and hard-working members; the University one of its most useful and distinguished graduates; and Australia one of its most eminent sons,

whose work was known and valued by astronomers and others throughout the world.

The Hon. Treasurer's Financial Statement for the year ended 31st March, 1907, was submitted to the meeting.

GENERAL ACCOUNT.

	RECEIPTS.	£ s. d.	£ s. d.
Subscriptions	One Guinea	54 12 0	
	" " Arrears	2 2 0	
	" " Advances ...	1 1 0	
	Two Guineas	361 4 0	
	" " Arrears	76 6 0	
	" " Advances ...	27 6 0	
			522 11 0
Parliamentary Grant on Subscriptions received—			
Vote for 1906-1907		271 15 6	
			271 15 6
Rent...			152 16 6
Sundries			25 17 9
Exchange added to Country cheques			0 1 0
Total Receipts			973 1 9
Balance on 1st April, 1906			32 5 7
			£1005 7 4

PAYMENTS.	£ s. d.	£ s. d.
Advertisements	0 13 0	
Attendances at Meetings...	9 0 0	
Assistant Secretary	250 0 0	
Books and Periodicals	118 6 4	
Bookbinding	9 9 0	
Collector	1 7 0	
Electric Light	3 17 1	
Freight, Charges, Packing, &c....	4 3 3	
Furniture and Effects	38 15 4	
Gas	15 18 8	
Housekeeper	7 10 0	
Insurance	10 1 10	
Installation of Electric Current for Lantern ...	15 0 0	
Interest on Mortgage	56 0 0	
Office Boy	4 18 4	
Petty Cash Expenses	9 19 2	
Postage and Duty Stamps	29 15 0	
Printing	30 4 6	

Payments—*continued.*	£ s. d.	£ s. d.
Printing and Publishing Journal	202 5 10	
Printing Extra Copies of Papers	5 13 0	
Rates	37 18 10	
Repairs	2 18 2	
Stationery	10 8 8	
Sundries	32 14 9	
Total Payments		906 17 9
Clarke Memorial Fund—Printing Circulars, &c.		0 13 0
Building and Investment Fund...		80 0 0
Bank Charges		0 18 7
Balance on 31st March, 1907, viz.:—		
Cash in Union Bank...		16 18 0
		£1005 7 4

BUILDING AND INVESTMENT FUND.

Dr.	£ s. d.	£ s. d.
Transfer from General Fund	80 0 0	
Deposit in Govt. Savings Bank 31st March '06	53 15 0	
Interest	1 6 3	
		135 1 3
Loan on Mortgage at 4%		1400 0 0
" " "		1510 0 0
		£3045 1 3

Cr.		£ s. d.
Balance 1st April, 1906		1400 0 0
Deposit in Government Savings Bank, March 31st, 1907	115 15 8	
Repairs to Building, &c.	19 5 7	
		135 1 3
Contractors on a/c	1450 0 0	
Architects on a/c	60 0 0	
		1510 0 0
		£3045 1 3

CLARKE MEMORIAL FUND.

Dr.	£ s. d.
Amount of Fund, 31st March, 1906	502 5 0
Interest to 31st March, 1907	16 18 0
	£519 3 0

Cr.	£	s.	d.
Honorarium and Expenses connected with delivery of three Lectures by Prof. E. W. Skeats, Oct. 22, 25 & 30, 1906	36	11	10
Deposit in Savings Bank of New South Wales, March 31, 1907	222	15	9
Deposit in Government Savings Bank, March 31, 1907 ...	259	15	5
	£519	3	0

AUDITED AND FOUND CORRECT, AS CONTAINED IN THE BOOKS OF ACCOUNTS.

F. BENDER .... }
WILLIAM EPPS... } *Honorary Auditors.*

SYDNEY, 24th April 1907.

D. CARMENT, F.I.A., F.F.A. *Honorary Treasurer.*
W. H. WEBB *Assistant Secretary.*

On the motion of the Hon. Treasurer, seconded by the President, it was resolved that the Statement be received and adopted.

On the motion of Mr. G. HOOPER, seconded by Mr. HENRY G. SMITH, a vote of thanks was passed to the Honorary Auditors, Mr. F. BENDER and Mr. WILLIAM EPPS.

ANNUAL REPORT OF THE COUNCIL.

The Council submit to the members of the Royal Society of New South Wales their Report for the year ended 30th April last.

The number of members on the roll on the 30th April, 1906, was 335, 30 new members have been elected during the past year. We have, however, lost by death 3 ordinary (and 1 Honorary) Members, and 11 by resignation. One member has failed to take up his membership. There is thus left a total of 350 on April 30th, 1907; this number, however, does not include the Honorary Members. The losses by death were:—

Honorary Member:

FOSTER, Sir MICHAEL, M.D., F.R.S., elected 1887

Ordinary Members:

NORTON, Hon. JAMES, M.L.C., LL.D., elected 1873
RUSSELL, H. C., B.A., C.M.G., F.R.S., elected 1864
YOUNG, JOHN, elected 1879.

Books and periodicals have been purchased at a cost of £118 6s. 4d., binding books amounted to £9 9s., making the amount spent upon the Library £127 15s. 4d.

The number of Institutions on the Exchange list is 425; publications received in exchange for the Society's Journal and Proceedings during the past year were:—235 volumes, 2,227 parts, 165 reports, 111 pamphlets and 3 maps, total 2,741.

During the past year the Society held eight meetings at which 14 papers were read: the average attendance of members was 31·7 and of visitors 1·6.

The Engineering Section held six meetings at which five papers were read and discussed.

On August 30th and September 3rd, a Conversazione in conjunction with the Enginneering Association, the Electrical Association, and the Institute of Architects was held in lieu of the usual Monthly Meeting.

POPULAR SCIENCE LECTURES.

A series of Popular Science Lectures, illustrated by lantern slides was delivered during 1906 at the Society's House, at 8 p.m., as follows:—

June 21—"*Some Results of Archæological Work in Jerusalem*," by Professor ANDERSON STUART, M.D., LL.D.

July 19—"*Our Water Supply from source to distribution*," by J. M. SMAIL, M. Inst. C.E., Engineer-in-Chief, Board of Water Supply and Sewerage, and E. S. STOKES, M.B., D.P.H., Medical Officer, Board of Water Supply and Sewerage.

Aug. 16—"*Sir Joseph Banks the 'Father of Australia'*," by J. H. MAIDEN, F.L.S., Director of the Botanic Gardens.

Sept. 20—"*Recent Developments in Long Distance Electrical Transmission*," by T. ROOKE, Assoc. M. Inst. C.E., City Electrical Engineer.

Nov. 15—"*Chapters in Early Australian History*," by F. M. BLADEN, F.R.G.S., F.R.H.S. (Lond.).

CLARKE MEMORIAL LECTURES.

A series of three lectures was delivered by Prof. E. W. SKEATS, D.Sc., F.G.S., Melbourne, University, on the following dates:—

Monday, October 22—"*The Volcanoes of Victoria,*"

Thursday, October 25—"*The Origin of Dolomite,*"—(α Early research and views as to its formation. β Experimental work up to the year 1897).

Tuesday, October 30—"*The Origin of Dolomite,*"—(α Recent experimental work including the chemical and mineralogical results of the examination of the Funafuti boring and of specimens from raised coral islands. β The bearing of these investigations on the origin of dolomite. γ Application of modern views to the dolomites of Tyrol and other areas.)

May 14, 1906, a lecture was delivered by His Honor JUDGE DOCKER, on "The Scenery of Mount Kosciusko," illustrated by lantern slides.

Professor T. P. ANDERSON STUART, M.D., LL.D., then read his address.

On the motion of Dr. SPENCER, seconded by Mr. CAMBAGE, a vote of thanks was passed to the retiring President, and Mr. HENRY DEANE, M.A., M. Inst. C.E., was installed as President for the ensuing year.

Mr. DEANE thanked the members for the honour conferred upon him.

ABSTRACT OF PROCEEDINGS, JUNE 5, 1907.

The General Monthly Meeting of the Society was held at the Society's House, No. 5 Elizabeth-street North, on Wednesday evening, June 5th, 1907.

H. DEANE, M.A., M. Inst. C.E., President, in the Chair.

Thirty-two members and three visitors were present.

The minutes of the meetings held December 5th, 1906, and May 1st, 1907, were read and confirmed.

Messrs. J. T. WILSHIRE and A. DUCKWORTH were appointed Scrutineers, and Mr. H. A. LENEHAN deputed to preside at the Ballot Box.

The certificates of three candidates were read for the third time, of four for the second time, and of five for the first time.

The following gentlemen were duly elected ordinary members of the Society:—

BURROWS THOMAS EDWARD, M. Inst. C.E., Civil Engineer, Public Works Department, Sydney.

GREEN, W. J., Chairman, Hetton Coal Co., Athenæum Club.

WEEDEN, STEPHEN HENRY, Civil Engineer, 'Kurrowah,' Alexandra-street, Hunter's Hill.

BOYD, ROBERT JAMES, B.E. Syd., Draftsman, Fitzroy-street, Burwood.

COBHAM, ALLAN BLENMAN, Secretary to the British Astronomical Association, N.S.W. Branch, 'Garthowen,' Myahgah Road, Mosman.

KALESKI, ROBERT, Agricultural Expert, The Hill, Holdsworthy, Liverpool.

SMITH, GUY PERCEVAL, B.Sc., Analytical and Manufacturing Chemist, c/o Ammonia Co. of Australia, Sydney.

The President made the following announcements:—

1. That the Society of Chemical Industry invited the members of the Royal Society to attend a meeting on the 12th June, at 8 p.m., to hear a paper by Mr. HENRY G. SMITH, F.C.S., on "Recent work on the Eucalypts and what it teaches," with lantern illustrations.

2. That the Second Popular Science Lecture of the Session would be delivered on Thursday, June 20, at 8 p.m., on "Some Polynesian and Melanesian Groups and the People who live in them," by Rev. GEORGE BROWN, D.D.

The following letter was read :—

The Observatory, May 6th, 1907.

To the Members of the Royal Society of New South Wales.

Dear Sirs,—Allow me on behalf of myself and family to offer you my very sincere thanks for the resolutions passed at your recent Annual General Meeting, of regret at my husband's death, and appreciation of his long and valuable services in connection with the Society. Also for your kindly message of sympathy, and believe me, yours faithfully,

EMILY J. RUSSELL.

THE FOLLOWING PAPER WAS READ:

"On some peculiarities in our coastal winds and their influence upon the abundance of fish in inshore waters," by H. C. DANNEVIG, Superintendent Fisheries Investigation, Department of Fisheries, N. S. Wales.

Remarks were made by Messrs. F. B. GUTHRIE, J. T. WILSHIRE, A. DUCKWORTH, and the President. The author replied.

Abstract of Lecture on "Some Polynesian and Melanesian Groups and the People who live in them," by Rev. GEORGE BROWN, D.D., delivered 20th June, 1907. Dr. BROWN stated that as the lecture was principally made up of a large number of slides which he purposed to exhibit, he could only give a few introductory remarks, more especially with regard to the two races about whom he wished to speak. He stated that the original habitat of the Melanesian and Polynesian races was a much disputed point, almost every writer on the subject having a separate theory on it. He could only state the conclusions to which he himself had come, admitting at the same time that there were many difficulties to the full acceptance of them which he was not prepared to explain. He thought it extremely likely

that there was originally one great Negrito race occupying the different groups as far west at least as Borneo, and probably extending upon the mainland on the side of Siam, the Malacca Peninsula, and perhaps as far as Burmah, which probably at that time formed part of one vast continent. The traces of these people are, or have been, found in several groups, notably in the interior of some islands in the Malay Peninsula, and also in New Zealand, where a black race was found by the original Maori colonists and derisively called by them "black kumara." Papuans of the present day are the oldest representatives of this race. In Malaysia, this Pre-Malayan race was modified by admixture with the Turanian races of the mainland of Asia, and probably also by an admixture from the mainland of India. This, he thought, constituted the present Polynesian race, which still retains so much of its old Papuan element. The lecturer stated that in his opinion this inter-mixture would probably account for some, if not all the differences, which exist to-day between the brown and the black races as they are found in the different groups. He stated that the Polynesians so formed, were the inhabitants of Malaysia prior to the irruptions of Malay and Hindu immigrants, by whom they were probably driven out and proceeded westward leaving perhaps some traces on the islands in their route, but were unable to form a settlement there owing to the presence of warlike Papuan races. He thought that the first home of the Polynesian tribes and from which they dispersed over the Eastern Pacific was at Manu'a, in the Samoan Group, to which place many of the Samoan traditions and many from Fiji and other groups all point. With regard to the languages spoken, he believed that much as they appear to vary on first acquaintance, they are radically all of one common stock, that the points of similarity between the two languages as in the construction and formation of nouns and adjectives, the existence

of the dual number in both, and traces of the trial in the Eastern Polynesian as in Tonga and Samoa, the use common to all of inclusive and exclusive pronouns, the reciprocal and causative forms of the verbs, the use of transitive terminations, and many other points are neither few nor insignificant as pointing to a common origin of both languages. This opinion is also strengthened by a comparison of the manners and customs of the different peoples, especially by the survivals in culture among the later Polynesians of the customs and traditions of their Papuan ancestors. This part of the lecture was illustrated by specimens of some words, notably such as 'ruma,' 'fale,' 'fanua,' which are common both to the Malay, Papuan and the Polynesian languages, and this the lecturer accounted for by the fact that they were in his opinion words in common use amongst the original peoples who inhabited the Malay Peninsula prior to the Malay irruption, and that became the common property of both races. They were in the language of the Papuan races, in that of the mixed races which constitute the brown Polynesian whom the Malays drove out, were adopted by the Malays, and so are found to-day in all the branches of these families. The lecturer then showed descriptive slides of the different places and the peoples who inhabit them, and also exhibited a very fine series of slides of the recent volcanic eruption in Samoa.

ABSTRACT OF PROCEEDINGS, JULY 3, 1907.

The General Monthly Meeting of the Society was held at the Society's House, No. 5 Elizabeth-street North, on Wednesday evening, July 3rd, 1907.

Prof. LIVERSIDGE, M.A., LL.D., F.R.S., in the Chair.

Thirty-four members and two visitors were present.

The minutes of the preceding meeting were read and confirmed.

One new member enrolled his name and was introduced.

Messrs. C. G. Hodgson and J. A. Schofield were appointed Scrutineers, and Mr. W. M. Hamlet deputed to preside at the Ballot Box.

The certificates of five candidates were read for the second time, and of two for the first time time.

The following gentlemen were duly elected ordinary members of the Society:—

Bogenrieder, Charles, Mining and Consulting Engineer and Metallurgist, 151 Victoria-street, Darlinghurst.

Hepburn Charles Graham, Assoc. M. Inst. C.E., Consulting Engineer and Patent Attorney, 169 King-street.

Johnson, T. R., M. Inst. C.E., Chief Commissioner of the New South Wales Railways, Sydney.

Smith, Horace Alexander, F.S.S., Assistant Actuary, Bureau of Statistics, 292 Miller-st., North Sydney.

Sutherland, David Alex. F.I.C., Consulting Engineer, Equitable Building, George-street.

The Chairman made the following announcements:—

1. That the third Popular Science Lecture of the Session would be delivered on Thursday, July 18th, at 8 p.m., on the "Bi-centenary of Linnæus' Birth," by J. H. Maiden, F.L.S.

2. That members could obtain copies of last year's volume on application to the Assistant Secretary.

3. Various circulars from the British Science Guild were laid upon the table for the information of the members present, and the objects of the Guild were explained by Prof. Liversidge, viz.:—

i. To bring together, as members of the Guild, all those throughout the Empire interested in science and scientific methods, in order by joint action to convince the people, by means of publications and meetings, of the necessity of applying the methods of science to all branches of human endeavour, and thus to further the progress and increase the welfare of the Empire.

ii. To bring before the Government the scientific aspects of all matters affecting the national welfare.

iii. To promote and extend the application of scientific principles to industrial and general purposes.

iv. To promote scientific education by encouraging the support of universities and other institutions where the bounds of science are extended, or where new applications of science are devised.

Thirteen volumes, 137 parts, 15 reports, and 6 pamphlets, total 171, received as donations since the last meeting were laid upon the table and acknowledged.

A circular was received from the National Museum of Natural History, Paris, initiating the opening of an international subscription in order to erect a statue of Lamarck in the "Jardin des Plantes."

The Chairman stated that the Hon. Secretaries of the Royal Society would be pleased to receive subscriptions which would be limited to five shillings.

The following resolutions were moved by Professor LIVERSIDGE and Professor WARREN, respectively, and duly carried :—

"The members of the Royal Society of New South Wales have learnt with great regret of the death of Sir MICHAEL FOSTER, K.C.B., M.D., F.R.S., an Honorary Member of the

Society since 1887, and they hereby express their appreciation of the inestimable value of his work in physiology, especially in the training of physiologists, and for his unremitting labours in the cause of science generally."

That the above resolution be forwarded to the late Sir MICHAEL FOSTER's family, as an expression of the Society's sympathy with them in their bereavement.

"The members of the Royal Society have learned with great regret of the death of Sir B. BAKER, K.C.M.G., K.C.B., F.R.S., etc., an Honorary Member of the Society, and they express their appreciation of the value of his services to the Empire in connection with the great engineering works which he has carried out, and his labours in engineering science."

That the above resolution to the late Sir B. BAKER be forwarded to his sister, Mrs. KEMP.

THE FOLLOWING PAPER WAS READ:

"Note on action of Nitric Acid in Neutralizing Alkaline Soil," by R. S. SYMMONDS. (Communicated by F. B. GUTHRIE, F.I.C., F.C.S.)

Remarks were made by Messrs. W. A. DIXON, W. J. CLUNIES ROSS and the Chairman. Mr. GUTHRIE replied.

By permission of the Chairman the paper by Mr. H. I. JENSEN, B. Sc., "Note on Copper in Andesite near Lautoka, Fiji," was postponed.

Mr. J. H. MAIDEN, F.L.S., then gave a lecturette on *Opuntias* or Prickly Pears. There are about one hundred and sixty valid species recorded; there are probably many more, but there are special difficulties in studying them. They cannot be studied in a room. Seven are acclimatised in New South Wales; one of them is harmless and even

valuable; one is almost harmless. The most commonly diffused one of New South Wales and Queensland is known to botanists as *Opuntia inermis* (unarmed), but this name was given by European botanists, who did not know how it behaved in the open. It is often known here as *Opuntia vulgaris*, but this name is wrong.

Prickly pears are not everything that is bad. In Sicily, Mexico, and other countries they are used to form humus and arrest soil in sterile situations. They have some horticultural value; they can be used as fodder for stock, but they are starvation food at the best. Analysis shows that they contain but little nutritive matter. If fed on enough prickly pear stock will not starve immediately, and they do to tide over a short period of scarcity. It is really a food adjunct, that is to say, if fed with bran, meal, and better fodder plants, it helps to get the best food results out of the scanty better foods with which it is admixed. Its chief value lies in the fact that it is a convenient way of conserving and of administering water; it is water in capsules. The fruits of one species found in New South Wales *(Opuntia ficus-indica)* are really useful, and I am endeavouring to select good ones for more extensive cultivation. These plants occasionally are seen in old-fashioned gardens, and now and then their fruit is sent to market. The outside of the fruit is armed with little irritating spinules, which must be first rubbed off with a cloth. The flesh of some is greenish-white, of others orange. The flesh of the prickly pear fruits which are a nuisance is of a rich carmine colour.

One is from time to time amused at the remedies proposed for the destruction of prickly pear, often the suggestion of people who have never been in country devastated by the pest. The problem of tackling large and badly infested areas often requires the expenditure of greater

capital than the land is worth; in many cases as land becomes divided into smaller areas and more under control, and more labour to work it, it will disappear, as an aggressive pest, like the rabbit. At the same time whenever it appears in a fresh place, war should be ruthlessly waged against it. Mechanical means of eradication seem to be the best, and chemical means to be subsidiary. Experience has shown that the best prickly pear killers contain arsenic as an active ingredient, a substance well known as poisonous to all vegetable and animal life. White arsenic is almost insoluble in water, but it readily dissolves if treated with caustic soda, and landowners should make their own weed-killers, and save the enormous profits of the man who simply does the mixing up.

By far the greater problem is the eradication of existing noxious prickly pears. Experiments have been made in the direction of obtaining a non-prickly pear, or a spineless cactus, as it is sometimes called. My own early experiments followed the lines, to some extent, of the late Prof. K. Schumann, of Berlin, the greatest authority on this group of plants in his day. But he laboured under the disadvantage of experimenting under unnatural conditions, since Germany is too cold for these plants to develop naturally. On my visit to Europe in 1900 I consulted Professor Schumann, and also inspected the principal collections of *Opuntia* in Europe. I brought to Australia specimens of the true *inermis*, given to me by Professor Schumann as the proper species from which it was most likely I should get a spineless form. In the genial climate of Australia it soon developed spines, and when it flowered and fruited I found that it was the same as the principal prickly pear which is such a pest in New South Wales and Queensland. I accordingly turned my attention to the so-called Indian fig (*Opuntia ficus-indica*), one of the principal

species which produces the edible fruit. I exhibit to you to-night the results, obtained by selection, and it is for you to judge whether we have got a spineless form or not. My experience, after years of careful watching, is that the spines are very few indeed, and that this plant can never be a pest. The only thing I fear is that stock will eat it out, but this can be got over by fencing and feeding to stock. I have already said that it is not in itself a valuable fodder plant, but I think that, as a water conserver in arid regions, and particularly in droughts, it has real value to the stockowner, while the fruits are liked by many people, and are certainly an addition to the scanty fresh fruit supply of the people of the west.

Remarks were made by Mr. W. A. DIXON, Dr. WALTER SPENCER, Mr. R. KALESKI, and the Chairman. Mr. MAIDEN replied.

ABSTRACT OF PROCEEDINGS, AUGUST 7, 1907.

The General Monthly Meeting of the Society was held at the Society's House, No. 5 Elizabeth-street North, on Wednesday evening, August 7th, 1907.

H. A. LENEHAN, F.R.A.S., Vice-President, in the Chair.

Twenty-three members were present.

The minutes of the preceding meeting were read and confirmed.

Mr. C. HEDLEY and Dr. G. HARKER were appointed Scrutineers, and Dr. WALTER SPENCER deputed to preside at the Ballot.

The certificates of two candidates were read for the second time, and of one for the first time.

The following gentlemen were duly elected ordinary members of the Society:—

CAMPBELL, ALFRED W., Medical Practitioner. 183 Macquarie-street.

WILEY, WILLIAM, Chief Assessor, Land Tax, 'Thurlow,' Neutral Bay.

The Chairman made the following announcements:—

1. That the Fourth Popular Science Lecture of the Session would be delivered on Thursday, August 15th, at 8 p.m., on "Our Health Resorts," by T. STORIE DIXSON, M.B., C.M. (Edin.).

2. That the First Clarke Memorial Lecture of the Session would be delivered on Thursday, August 22nd, at 8 p.m., on "The Geography of Australia in the Permo-Carboniferous Period," by Prof. T. W. E. DAVID, B.A., F.R.S.

Thirty-five volumes, 198 parts, 33 reports and 8 pamphlets, total 274, received as donations since the previous meeting, were laid upon the table and acknowledged.

THE FOLLOWING PAPERS WERE READ:

1. "Note on Copper in Andesite from near Lautoka, Fiji," by H. I. JENSEN, B. Sc. (By permission of the Council of the Linnean Society of New South Wales.)

2. "Analysis of a specimen of Sea-water from Coogee, New South Wales," by C. J. WHITE, Caird Scholar, University of Sydney. (Communicated by Professor LIVERSIDGE, LL.D., F.R.S.)

3. "Notes on some Aboriginal Tribes," by R. H. MATHEWS, L.S.

Remarks were made by Dr. WALTER SPENCER, Mr. C. Hedley, and the Chairman.

4. "Note on the action of lime on the available soil constituents," by F. B. GUTHRIE, F.I.C., F.C.S., and L. COHEN.

Remarks were made by Mr. LOXLEY MEGGITT, Mr. J. A. SCHOFIELD, and Prof. LIVERSIDGE. The authors replied.

EXHIBIT.

Mr. H. A. LENEHAN exhibited a series of enlarged photographs of the comet now visible; also a graphic model of the comet's orbit, supplied by Mr. G. BUTTERFIELD.

Abstract of lecture on "Our Health Resorts," by T. STORIE DIXSON, M.B., C.M. (Edin.), delivered 15th August, 1907.—The lecturer first directed attention to the fact that though in the earlier days of the colonies, Australia had a considerable reputation as a health resort, more especially for consumptives, in one of the most recent books on Climatotherapy, published in Great Britain, the only reference to this continent was included in five lines descriptive of the climate of Melbourne. Even though we may not wish to import invalids from other countries, for the sake of our own sufferers we should make the most of our opportunities; that we have failed to do this, is in part due to the sparseness of our population. In later years, thanks chiefly to the efforts of the late Mr. H. C. RUSSELL, most valuable and detailed information has been placed at our disposal. In many respects our coast has advantages unequalled in Great Britain, or indeed in Europe. The purity of the sea-water and its warmth even in winter, are only rivalled on the shores of the Mediterranean. The facilities for sea-bathing, boating, and other salutary exercises, added to the cheering effect of the exquisite scenery

of our coast is too little made use of. Where the coastline is lofty, there is a very distinct lowering of the rainfall of the intracoastal plains *e.g.*, Camden. The eastern side of the mountain ranges has such a power in precipitating moisture from the air, that even at Mount Victoria the average rainfall is very decidedly less than at Katoomba. In cases where considerable elevation might be desirable, with a relatively light rainfall we can find it readily, *e.g.*, Guyra Lake, and where still greater elevation is required, there is the "Hospice" at Mount Kosciusko at about 6,000 feet high, and it is quite possible that in this neighbourhood we may find as regards height above sea-level combined with stillness of air a rival to the world-famed Davos in Switzerland. The inland plains were contrasted with the Nile country of Egypt. The spa waters of New South Wales, though few in number, are fortunately of great variety, and of their kind probably not surpassed by the corresponding waters of Europe and America. Great stress was laid upon the necessity of using the natural advantages of our varied climate in the treatment of the poorer class of invalids of our own country, so that especially in the case of the convalescents of our city hospitals, and of those suffering from chronic ailments who have to be treated as out patients, we might not only greatly facilitate their recovery, but even make cures possible, which otherwise might be unobtainable; in this respect only imitating the excellent example set by Germany and other European countries.

ABSTRACT OF PROCEEDINGS, SEPTEMBER 4, 1907.

The General Monthly Meeting of the Society was held at the Society's House, No. 5 Elizabeth-street North, on Wednesday evening, September 4th, 1907.

H. A. LENEHAN, F.R.A.S., Vice-President, in the Chair.

Twenty-seven members and one visitor were present.

The minutes of the preceding meeting were read and confirmed.

Two new members enrolled their names and were introduced.

Messrs. C. G. HODGSON and J. BROOKS were appointed Scrutineers, and Mr. W. M. HAMLET deputed to preside at the Ballot Box.

The certificate of one candidate was read for the second time.

The following gentleman was duly elected an ordinary member of the Society:—

FREEMAN, WILLIAM, 117 Pitt-street.

The Chairman made the following announcements:—

1. The Second Clarke Memorial Lecture 1907, will be delivered on Wednesday, September 11th, at 8 p.m. by Prof. DAVID, (instead of Mr. W. S. DUN's lecture previously announced for this date and which is now postponed). Professor DAVID will deliver Part II. of "The Geography of Australia in the Permo-Carboniferous Period," viz.:—Theories as to the cause of the remarkable Glaciation in Early Carboniferous Time.

2. That the Fifth Popular Science Lecture 1907, will be delivered on Thursday, September 19th, at 8 p.m., on "Further Chapters in Early Australian History," by F. M.

BLADEN, F.R.G.S., F.R.H.S. (Lond.), Principal Librarian, Public Library, Sydney.

3. The Council intended to hold a Conversazione this Session, but it has been found necessary to postpone it until next year.

4. The Chief Commissioner for Railways (Mr. T. R. JOHNSON) has kindly invited the members of the Royal Society to visit the Power House any afternoon to be arranged, from 4·30 to 5·30. Names of intending visitors should be notified to the Honorary Secretaries.

5. The Institute of Architects of New South Wales has kindly invited the members to attend a meeting to be held in this Hall to-morrow night at 8 o'clock, when a paper will be read by Mr. F. WALKER on "The Vice-Regal Residences in New South Wales," illustrated by lantern slides.

THE FOLLOWING PAPERS WERE READ:

1. "The One-wheeled Car," by LAWRENCE HARGRAVE.
2. "The Steady Deflection Method of Current Measurement with an Electrometer," by J. A. POLLOCK, Professor of Physics in the University of Sydney.

EXHIBITS:

Mr. J. H. MAIDEN exhibited and described a number of interesting botanical specimens illustrating stem-fasciation in various genera of plants, and drew attention to the experiments of Miss A. A. KNOX of New York, who has shown that stem-fasciation is caused, in specimens examined by her, by attacks of insects on the growing tips of the plants.

He called the attention of members to the fact that no notice was necessary in regard to exhibits, and that if members would at the General Monthly Meetings be kind enough to bring along any object they might think of interest, the Council would be extremely obliged.

ABSTRACT OF PROCEEDINGS, OCTOBER 2, 1907.

The General Monthly Meeting of the Society was held at the Society's House, No. 5 Elizabeth-street North, on Wednesday evening, October 2nd, 1907.

H. DEANE, M.A., M. Inst. C.E., President, in the Chair.

Thirty-four members were present.

The minutes of the preceding meeting were read and confirmed.

One new member enrolled his name and was introduced.

The Chairman made the following announcements, viz.:

1. That the following Clarke Memorial Lectures would be delivered this month:—

Oct. 9th—"The Geological relations of Oceania," by Dr. W. G. WOOLNOUGH.

Oct. 31st—"Problems of the Artesian Water Supply of Australia," by E. F. PITTMAN, A.R.S.M., Under Secretary and Government Geologist, Department of Mines.

2. That the Sixth (and final) Popular Science Lecture of the Session would be delivered on Thursday, October 17th at 8 p.m., on "Regeneration and Recent Biological Experiment, by Prof. J. T. WILSON, M.B. (Edin.)

3. The Council invite members to take advantage more frequently of the opportunity of exhibiting objects of interest at the Monthly Meetings. No notice of intention to exhibit is necessary except when members desire an intimation to appear in the circular convening the meeting. The circular is sent to press on the afternoon of the Thursday preceding the meeting.

Nineteen volumes, 191 parts, 16 reports, and 6 pamphlets, total 232, received as Donations since the previous meeting were laid upon the table and acknowledged.

THE FOLLOWING PAPERS WERE READ:

1. "Law of Meteorological Phenomena," by A. G. WILLIAMS. (Communicated by Prof. T. W. E. DAVID, F.R.S., and read by T. W. KEELE, M. Inst. C.E.)

The President stated that the paper would be printed in galley form and distributed to members prior to the next meeting, so that it might be discussed.

2. "A simple form of Sprengel Vacuum Pump," by J. A. POLLOCK, Professor of Physics in the University of Sydney.

A modified short fall Sprengel vacuum pump of moderate dimensions is described, in which the raising of the mercury, necessary for continuous working, is effected by evaporating the mercury at a lower and condensing it at a higher level.

Some remarks were made by Professor LIVERSIDGE.

3. "Note on the Internal Structure of some Gold Crystals," by A. LIVERSIDGE, LL.D., F.R.S., Professor of Chemistry in the University of Sydney.

Professor LIVERSIDGE exhibited sections of isolated crystals and groups of gold crystals, mainly octahedra and rhombic dodecahedra, and photographs of the same before and after cutting. The simple faces on polishing and etching showed that the internal structure did not correspond with the external; *e.g.*, in one case the rhombic planes of an externally simple dodecahedron, were found to be made up of two triangular faces; on these triangles there were also faces of smaller crystals. Some showed a still more complex structure.

EXHIBITS:

Mr. Henry G. Smith, F.C.S., exhibited artificial (synthetic) camphor which has recently been received by the Technological Museum. The successful manufacture of synthetic camphor has now become possible, due chiefly to the high price of the natural camphor, and to its use in such large quantities in the celluloid industry. Much time and money have recently been expended in perfecting the manufacture of the synthetic product, which is identical in composition with the natural camphor, only differing from the natural product in being inactive to light. The preparation is, however, only a partial synthesis, but it differs entirely from the old "artificial camphor" which is produced when dry hydrochloric acid gas is passed into dry turpentine. The basis of the manufacture of synthetic camphor is the production of the terpene camphene from the terpene pinene which occurs so largely in ordinary turpentine. Many methods are now known for the preparation of camphene, which product is now a commercial article. By suitable treatment camphene can be transformed into isoborneol, and when this is oxidised camphor is formed. Camphor is thus the ketone of the secondary alcohol isoborneol. Borneol and isoborneol can be obtained when camphor is suitably reduced. Other partial syntheses of camphor are known chiefly those of the formation of isobornyl esters of such acids as salicylic and oxalic. A process in which the latter acid was used was worked under the Thurlow patent, but its manufacture by this process now seems to have been abandoned.

Mr. J. H. Maiden exhibited, on behalf of Mr. C. J. McMaster, President, Western Lands Board, a portion of a boot-upper compactly pierced by the awns of a grass, *Bromus sterilis*, L. The wearer of the boot was travelling

near Hampstead, Queensland. Also five water-colour drawings by Miss MARGARET FLOCKTON, of *Phyllocacti* showing various shades of colour from pure white to crimson and even scarlet. These plants were raised by Mr. GEORGE HARWOOD, Botanic Gardens, Sydney, from seeds taken from one capsule! Specimens such as these show the difficulties of the hybridiser in breeding for colour in *Phyllocactus*.

Mr. W. J. MACDONNELL exhibited a solar prominence spectroscope by Thorpe of Manchester, with transmission grating attached to prism, dispersion equal to five flint prisms. D lines of spectrum widely separated and nickel line visible between them.

ABSTRACT OF PROCEEDINGS, NOVEMBER 6, 1907.

The General Monthly Meeting of the Society was held at the Society's House, No. 5 Elizabeth-street North, on Wednesday evening, November 6th, 1907.

H. A. LENEHAN, F.R.A.S., Vice-President, in the Chair.

Thirty-five members and one visitor were present.

The minutes of the preceding meeting were read and confirmed.

One new member enrolled his name.

The Chairman made the following announcements, viz.:—

1. That the Council had awarded the Clarke Memorial Medal to Mr. WALTER HOWCHIN, F.G.S., Adelaide.

2. That the fifth (and Final) Clarke Memorial Lecture of this Session would be delivered on Monday, November 18th at 8 p.m., on "The Permo-Carboniferous Fauna and its relations." by W. S. DUN, Palæontologist, Department of Mines.

3. That the monthly meeting of the Engineering Section would be held on Wednesday, November 20th, at 8 p.m.

The certificate of one candidate was read for the first time.

Thirty volumes, 219 parts, 10 reports, 7 pamphlets, and 13 maps, total 279, received as donations since the previous meeting, were laid upon the table and acknowledged.

The following letter was read:—

Bowden Green, Pangbourne, Berks,
August 27, 1907.

Mrs. Kemp and family return grateful thanks for kind letter sent in sympathy for the great loss of her brother Sir Benjamin Baker, also for the kind expressions of appreciation of his work.

THE FOLLOWING PAPERS WERE READ:

1. "Notes on the Arranda Tribe," by R. H. MATHEWS, L.S.

2. "A short accurate method for the estimation of iron, alumina and phosphoric acid when occurring together," by THOMAS COOKSEY, Ph.D., B.Sc.,

Some questions were asked by Mr. J. A. SCHOFIELD.

3. "Note on the formation of formaldehyde in solutions of cane sugar and its bearing on Hehner's test for formaldehyde in saccharine mixtures," by A. ALEXANDER RAMSAY.

In the author's absence, the paper was read by Mr. F. B. GUTHRIE.

Remarks were made by Dr. HARKER, Mr. J. A. SCHOFIELD, Professor LIVERSIDGE, and Dr. COOKSEY. Mr. GUTHRIE replied.

The paper by Mr. A. G. Williams on "Law of Meteorological Phenomena" (read at the previous meeting) was then discussed.

The Chairman read some remarks he had prepared on the subject, other notes written by the President and Mr. H. I. Jensen were (in the absence of the writers) read by Mr. Maiden.

By permission of the Chairman, Mr. T. W. Keele read three additional pages of manuscript which had been forwarded by the author (Mr. A. G. Williams) and showed a number of lantern slides that he (Mr. Keele) had had prepared from additional charts received.

The following gentlemen also took part in the discussion: Messrs. J. Brooks, W. J. Clunies Ross, E. DuFaur, C. J. Merfield, G. H. Halligan, and A. Duckworth.

EXHIBIT:

Mr. R. T. Baker, F.L.S., Curator, Technological Museum, exhibited specimens of the New Zealand Mountain Composites, *Raoulia eximia*, Hook., f. and *R. mammilaris*, Hook., f., plants commonly known as "Vegetable Sheep." They are found in the Alps of that Dominion, at altitudes varying from 3,000 to 6,000 feet, where they form hemispherical woolly cushions varying in diameter and height from a few inches to eight feet, and three feet respectively. The largest specimen exhibited measured 2 ft. 6 in. diam. and 14 inches high. The close compact hairs at the end of the minute leaves give the plant an appearance that is uncommonly like the back of a Merino sheep.

ABSTRACT OF PROCEEDINGS, DECEMBER 4, 1907.

The General Monthly Meeting of the Society was held at the Society's House, No. 5 Elizabeth-street North, on Wednesday evening, December 4th, 1907.

H. DEANE, M.A., M. Inst. C.E., President, in the Chair.

Thirty members and five visitors were present.

The minutes of the preceding meeting were read and confirmed.

Mr. WILLIAM EPPS and Mr. W. P. MINELL were appointed Auditors for the current year.

His Honor Judge DOCKER and Mr. R. H. CAMBAGE were appointed Scrutineers, and Mr. HENRY G. SMITH deputed to preside at the Ballot Box.

The certificate of one candidate was read for the second time.

The following gentleman was duly elected an ordinary member of the Society:—

DAVYS, HUBERT JOHN, M.E., 37 Wynyard Square.

Thirty-one volumes, 264 parts, 6 reports, 6 pamphlets and one map, total 308, received as Donations since the previous meeting, were laid upon the table and acknowledged.

The following letter from Mr. WALTER HOWCHIN, F.G.S., University of Adelaide, was received and read:—

The University of Adelaide, November 12th, 1907.

J. H. MAIDEN, Esq., F.L.S., Hon. Sec., Roy. Soc., N.S.W.

Dear Sir,—I have the honour to acknowledge receipt of your favour of the 5th inst., conveying the information that the Council of the Royal Society of New South Wales had awarded me the Clarke Memorial Medal. I have also to acknowledge the receipt, by same mail, of the medal in question. I am deeply grateful to the Council of the Royal

Society of New South Wales, for this mark of appreciation of my scientific labours. Whilst the pursuit of truth is, in itself a sufficient incentive to research, I esteem, very highly, the approbation and encouragement of my fellow workers, and the honour which your Council has kindly conferred upon me will act as an additional stimulus in my scientific investigations. I am, dear Sir, yours very truly,

WALTER HOWCHIN.

The following resolutions were moved by Prof. LIVERSIDGE seconded by Mr. F. B. GUTHRIE and duly carried:—

1. That the members of the Royal Society of New South Wales learn with deep regret of the death of Sir JAMES HECTOR, K.C.M.G., M.D., F.R.S., one of its earliest Honorary Members, and they hereby place on record their high appreciation of his scientific services as an explorer, geologist, and as an ardent worker for the advancement of science generally.

2. That the above resolution be forwarded to the late Sir JAMES HECTOR'S family as an expression of this Society's deep sympathy with them in their bereavement.

THE FOLLOWING PAPERS WERE READ:

1. "The effect of Polar Ice on the weather," by E. DU FAUR, F.R.G.S.

A discussion ensued in the which the following gentlemen took part, viz:—Mr. H. A. LENEHAN, Dr. SPENCER, Messrs. R. MCMILLAN, W. J. CLUNIES ROSS, T. W. KEELE, Prof. LIVERSIDGE, and the President. Mr. DU FAUR replied.

2. "A comparison of the rainfall of Sydney and Melbourne, 1876 to 1905," by A. DUCKWORTH, F.R.E.S.

On the motion of Mr. LENEHAN the discussion was postponed.

3. "The Australian Melaleucas and their essential oils," Part II., by R. T. BAKER, F.L.S., Curator, and HENRY G. SMITH, F.C.S., Assistant Curator, Technological Museum, Sydney.

With the consent of the authors, and owing to the lateness of the hour, the following papers were taken as read.

4. "Aboriginal Navigation and other notes," by R. H. MATHEWS, L.S.

5. "A short volumetric method for the estimation of sulphuric acid," by THOMAS COOKSEY, Ph. D., B. Sc.

EXHIBITS:

A large and interesting series of exhibits illustrating their paper was shown by Messrs. BAKER and SMITH.

Mr. R. T. BAKER, on behalf of Mr. F. U. OAKES, exhibited several turpentine piles, which had been driven in the waters of Leycester Creek, Lismore, about five years ago; these waters are fresh, but have a tide rise and fall of from two to three feet. These piles have been absolutely destroyed by the ravages of the *Teredo navalis* during that time.

The following donations were laid upon the table and acknowledged:—

TRANSACTIONS, JOURNALS, REPORTS, &c.

(The Names of the Donors are in *Italics.*)

AACHEN—Meteorologische Observatoriums. Deutsches Meteorologisches Jahrbuch für 1905, Jahrgang XI. *The Director.*

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PROCEEDINGS

OF THE

ENGINEERING SECTION.

PROCEEDINGS OF THE ENGINEERING SECTION.

(IN ABSTRACT.)

The Annual General Meeting of the Engineering Section was held on Wednesday, 15th May, 1907.

Mr. J. H. Cardew, in the Chair.

Twenty-five members and visitors were present.

There being no other nominations, the following gentlemen were elected officers and members of committee for the current year:—

Chairman: T. W. Keele, M. Inst. C.E.

Hon. Secretary: W. E. Cook, M.E., M. Inst. C.E.

Committee: H. G. McKinney, M.E. M. Inst. C.E.
J. M. Smail, M. Inst. C.E.
T. H. Houghton, M. Inst. C.E., M.I. Mech. E.
G. R. Cowdery, Assoc. M. Inst. C.E.
Norman Selfe, M. Inst. C.E., M.I. Mech. E.
J. I. Haycroft, M.E.
R. T. McKay, L.S., Assoc. M. Inst. C.E.
F. M. Gummow, M.C.E.
Algernon Peake, Assoc. M. Inst. C.E.

Past Chairmen: S. H. Barraclough, B.E., M.M.E. M. Inst. C.E.
J. Davis, M. Inst. C.E.
J. Haydon Cardew, Assoc. M. Inst. C.E.

The retiring Chairman, Mr. J. H. Cardew, then read his address entitled "Engineering development in relation to some Australian problems," illustrating the address by two large wall diagrams, one showing the density of population in India, China, Japan, Australia, etc, and the other the various strategetical railways referred to.

At the conclusion of his address Mr. CARDEW installed Mr. T. W. KEELE, the newly elected Chairman.

A vote of thanks was passed to the retiring Chairman.

The retiring Chairman having asked members to discuss the various questions touched on in the address, the following briefly discussed portions of it: Messrs. SELFE, DEANE, WILKIN, and SMAIL.

The Chairman suggested that the address should be discussed in two parts, viz :—

1. (*a*) Unification of railway gauge.
   (*b*) Strategetical railways for development and defence purposes.
2. Municipal decentralization and greater Sydney

on separate future evenings. This was decided on.

Exhibit—Mr. WILKIN exhibited a model of Mr. BRENNAN'S third-rail device for overcoming difficulties at points and crossings.

General Monthly Meeting, Wednesday, 19th June, 1907.

Mr. T. W. KEELE, in the Chair.

Twenty-three members and visitors were present.

The minutes of the preceding meeting were read and confirmed.

The discussion on retiring Chairman's address—

(*a*) The unification of railway gauges.

(*b*) Strategetical railways for development and defence purposes

then followed.

After a few introductory remarks by the Chairman, the following gentlemen took part in the discussion Messrs. DEANE, WILKIN, SIMPSON, COWDERY, C. W. SMITH, Lt.-Col. HOLMES, BARRACLOUGH, DALY, TAYLOR and COOK.

Exhibit—Mr. WILKIN exhibited an improved model of Mr. BRENNAN's third-rail device for overcoming difficulties at points and crossings.

General Monthly Meeting, Wednesday, 17th July, 1907.

Mr. T. W. KEELE, in the Chair.

Twenty-five members and visitors were present.

The minutes of previous meeting were read and confirmed.

The discussion on retiring Chairman's address—'Municipal decentralization and greater Sydney,' then followed.

The following gentlemen took part in the discussion—Alderman LEAHY, Mayor of Mosman, Messrs. SELFE, McDOUGALL, SMAIL, BAVIN, and MERIVALE.

Owing to the late hour it was then decided to adjourn the discussion till next meeting.

General Monthly Meeting, Wednesday, 21st August, 1907.

Mr. T. W. KEELE, in the Chair.

Eleven members and visitors were present.

The minutes of previous meeting were read and confirmed.

The adjourned discussion on retiring Chairman's address 'Municipal decentralization and greater Sydney' then took place. The following gentlemen took part in the discussion Messrs. CYRIL BLACKET, HOUGHTON, and WILKIN.

Mr. J. H. CARDEW then replied at considerable length to the remarks of the various speakers on the three evenings over which the discussion had extended.

Mr. J. FURNISS was present to read his paper on 'Pumps,' but at the suggestion of the Chairman it was decided to postpone it till next meeting.

General Monthly Meeting, Wednesday, 18th September, 1907.

Mr. T. W. Keele, in the Chair.

Thirty members and visitors were present.

The minutes of previous meeting were read and confirmed.

Mr. J. F. Furniss read a paper on 'Pumps' dealing with those used by the Water and Sewerage Board from the earliest beam type used at Botany to the most modern electrically driven type now in use at Crown Street Station. A very large number of lantern slides were shown in illustration of the author's remarks.

A vote of thanks was passed to the author. At the request of several members the Chairman promised to have the paper printed and circulated among members without delay.

General Monthly Meeting, Wednesday, 16th October, 1907.

The meeting was allowed to lapse because there had been a delay in printing Mr. Furniss' paper on 'Pumps.'

General Monthly Meeting, Wednesday, 20th November, 1907.

Mr. T. W. Keele, in the Chair.

Ten members were present.

The discussion on Mr. Furniss' paper on 'Pumps' then took place, being opened by the Chairman. The following gentlemen took part in the discussion, Messrs. Selfe, Shirra, Kilburn Scott, Price, Smail and Houghton.

Mr. Furniss replied and again exhibited lantern views to illustrate his remarks. A hearty vote of thanks was accorded to the author.

Visits.

On Wednesday, 24th July, the members of the Section were invited by the Public Works Committee to visit Parliament House, Macquarie Street, to inspect a working

model, representing the proposed ocean outfall scheme for Illawarra and Western Suburbs, together with the action of the waves on the main sewer at outfall.

Mr. T. W. KEELE (Chairman) and thirty members accepted the invitation. They were welcomed by the Chairman of the Public Works Committee, who then asked Messrs. PEAKE and HALLIGAN to explain the model which they did at considerable length.

By the courtesy of Mr. L. A. B. WADE, M. Inst. C.E., Engineer for Water Supply and Sewerage, members were each supplied with a type written description of the arrangement.

On Friday, 18th October, 1907, the Engineering Section together with members of the following societies, the Engineering Association, the Electrical Association of N.S. Wales, the Institute of Architects, the University Engineering Society, and the Society of Chemical Industry paid a visit to the Lithgow Ironworks. On arrival at Eskbank they were welcomed by Mr. W. SANDFORD and Major PENNYMORE the Manager.

The blast furnace and surroundings were first inspected, then a visit was paid to the rolling mills situated some distance away.

Some of the party also visited the Cobar Smelting Works and were shown round by the manager.

CHAIRMAN'S ADDRESS.

By J. HAYDON CARDEW, Assoc. M. Inst. C.E.

[*Read before the Engineering Section of the Royal Society of N. S. Wales, May 16, 1907.*]

OF late years it has been the practice of the retiring Chairman of the Engineering Section, to give an address to the members on the last night of his occupancy of the chair; this procedure was arranged by the Committee in preference to the custom which prevails in other similar societies of the incoming chairman giving an address on the first night of his term of office, the idea being, that the chairman who has been your spokesman for the last twelve months, is more fully seized with the doings of the Section, and has more time and fuller opportunities for the preparation of an address that is likely to meet with the acceptance and approval of his audience. The subject matter of such an address is always a question of difficulty, not so much because of the lack of material, but more particularly because of its abundance. Another difficulty to be contended against in the preparation of such an address is, that we, being so far distant from the centre of the world's greatest activities, can only follow the rapid and startling developments that are daily taking place, through the medium of engineering journals, and consequently the eye is unable to picture on the brain, an adequate idea of what is taking place, and accounts of the most important occurrences and discoveries in engineering reach us so late, as to be mere echoes of great achievements.

Speaking as an engineer to engineers, who are Australians either by birth or adoption, and practical men of the world and not mere theorists, I apprehend that the subject

likely to meet most readily with your approval, would be engineering in its practical application to some of the problems of Australian life, and its consequent development. Therefore I propose to designate my address "*Engineering development in relation to some Australian problems.*"

That there are Australian problems of enormous difficulty to be dealt with, all thinking men and observers of the signs of the times will concede, and I make bold to assert that in the solution of them, the engineer will be called upon to take a prominent part.

First and foremost, we have to solve the riddle of how to develop and make habitable this vast continent of Australia, so that it may be held against all comers, for the benefit of the Anglo-Saxon race. At present we are but a small handful of white people holding one of the most advanced outposts of the British Empire in close proximity to the vast empires of China and Japan, who, until a few years ago, were regarded by the European nations as barbarians, and were bullied by them accordingly, but who to-day have so successfully copied their tormentors, that if they cannot be called civilised after our code, are so advanced as to know the value of ships and guns, and well drilled soldiers, and are busy acquiring them. As long as European affairs are tranquil, and our relations with Japan are such as to suit her book all may be well, but China will always be a menace to Australia, undeveloped and unpeopled; at present she is drilling, disciplining and equipping soldiers with the aid of European instructors, she is being taught how to build railways by British speculators, and to build ships, equip dockyards, build arsenals, and construct big guns by the Japanese, and in ten years expects to have an expert army numbered by millions and a navy equally strong. For what purpose it may be asked? No definite answer can be given, but China is crowded to

excess with a teeming population, for which there is no outlet except southwards, and it is sufficient for us to be prepared to stem the overflow, if it comes in our direction. Some lunatic may at any day drop a match into the combustible material of European politics, which might give Great Britain all she could do to hold her own, or at all events might necessitate the temporary abandonment of this isolated outpost, and the opportunity might be seized by China to pour her surplus millions into the northern territory, unless in the meantime we take the precaution to stock it for ourselves with some sturdy pioneering race who will hold it for the empire.

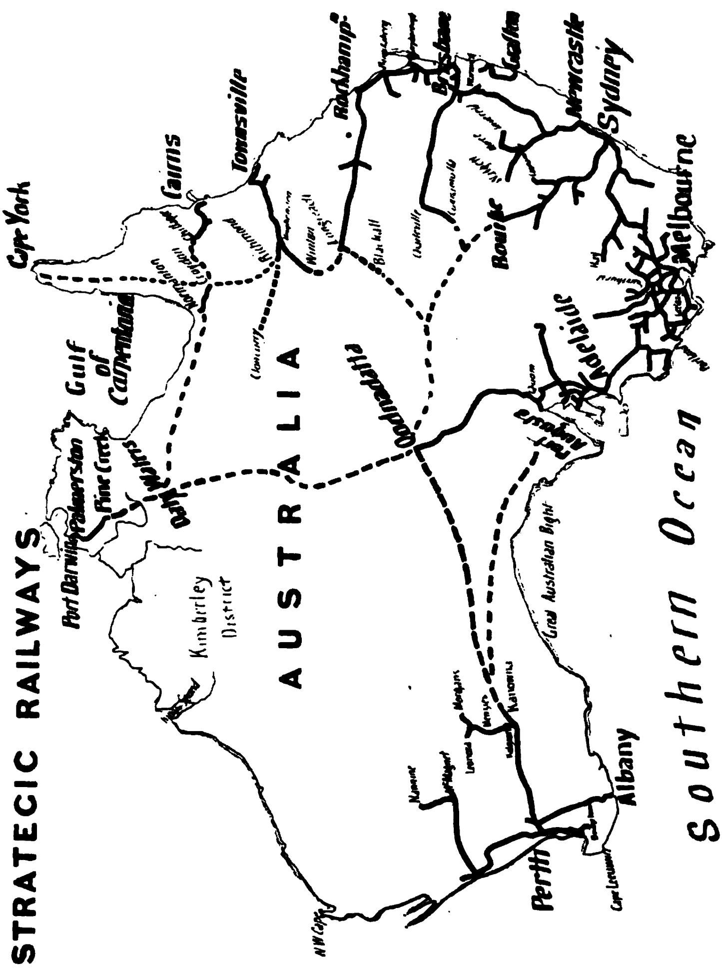
A policy of internal development and settlement of population would be more effective than a standing army, but the accomplishment of such a gigantic undertaking would necessitate the construction of internal lines of communication, which at once brings us to the consideration of the problem in relation to Australian railways.

Engineering and Australian Problems in relation to Australian Railways.—The principal object of a railway system in a new country such as Australia, when viewed from a national standpoint, should be the development of its resources, in order that people of our race and of similar aspirations, and having the same destiny, may "go in and possess the land" and be able to hold it against intrusion of the outsider and the alien, and when the system is under State ownership, the construction of lines which *per se* are unremunerative, may be fully justified if the trade and industries of the country are stimulated, and the whole system is benefited by the increased volume of traffic accruing thereby. In some cases it may be sound policy for the Government to sacrifice revenue in order to foster a trade or an industry that may be necessary for the defence of the country, or that may induce population to

settle on the land; such an instance may be found in the recent arrangements made with William Sandford and Co. by the New South Wales Government for the establishment of the iron industry at Lithgow. Private enterprise cannot do these things and pay dividends.

When the Government of New South Wales made its first venture in State ownership by taking over the construction of the first Australian Railway from Sydney to Penrith, which had been started by private enterprise, it did so reluctantly, and not with any fixed idea of pursuing a policy of development, but rather it was forced into the position of State ownership by the exigency of circumstances, but during the past fifty years, and since that event, the principles that govern state ownership of railways have gradually evolved, perhaps largely due to the example set by the British Government in India, until at the present day state ownership may be regarded as the fixed policy of Australia. During the currency of the old colonial system, the policy adopted by each colony in the control of its railways, has been for the benefit of the respective colonies owning them, but it is very doubtful whether these methods which are still in force, will continue to confer the same benefits upon the Federated States of Australia as a whole. The great economic changes in the far East and the rise of Japan to a great world power, are potent factors in the condition of our circumstances of to-day, which we cannot afford to ignore; our vast areas of unoccupied land, our huge deposits of minerals, our great wealth of exports, and withal our colour exclusiveness, are making us the object of envy and covetousness to the Mongolian and other races that surround us.

The diagram exhibited on the screen is taken from Cole's Cosmopolitan Reasoner, a Sydney publication, and it illustrates in a striking manner the density of the population of Australia as compared with some of her neighbours.


STRATECIC RAILWAYS
Cape York
Cairns
Townsville
Rockhampton
Brisbane
Grafton
Newcastle
Sydney
Melbourne
Bourke
Adelaide
Port Augusta
Oodnadatta
Gulf of Carpentaria
Port Darwin
Palmerston
Pine Creek
Daly Waters
Kimberley District
AUSTRALIA
Great Australian Bight
Southern Ocean
Albany
Perth
Kanowna

Australia, which comprises about three millions of square miles, has a population of less than five millions, increasing very slowly.

Japan, is about one-eighteenth the size of Australia, and contains forty-six millions of people, increasing at the rate of about half a million per annum, and is only sixteen days steam from Australia.

India proper, is about half the size of Australia, and contains three hundred millions of people, increasing at the rate of one million per annum, and is only fourteen days steam from Australia.

China proper, is about half the size of Australia, contains four hundred millions of people, increasing at the rate of more than one million per annum, and is only fourteen days steam from Australia.

Java is about one-sixteenth the size of Australia, contains thirty millions of inhabitants, increasing at the rate of six times greater than the Australian population, and is only four days steam from our shores.

Hence, it will be observed that seven hundred and seventy-six millions of people, or nearly *half the population of the whole world*, live in the countries mentioned, on an aggregate area very little greater than the continent of Australia, and all within a few days steaming of our unoccupied territory. These countries have increased their aggregate population by about sixty millions in twenty years, while the continent of Australia has only increased her population by about two millions. It is clear that we cannot hold our vast area of land in an unoccupied and undeveloped state for an indefinite period, and unless we can induce the overflow of European population to fill up our waste places, the ideal of a *White Australia* is impossible of achievement, and we are in danger of being submerged by an overflow of alien peoples.

The rise of the Japanese to eminence amongst the nations of the world, is unlocking the imagination of all yellow races which has been slumbering for centuries, and which when it does wake will start refreshed and invigorated for the prosecution and achievement of the greatest revolution the world has ever seen. I am not painting any fancy picture; these are facts that we have to face and consider. If we wish to keep our great possessions inviolate, we have only two alternatives, internal development now, or war hereafter. In modern development or modern war, the railways of a country play a most important part, and are vital for the prosecution of both; for those purposes it is necessary that they should be well equipped, well managed, and be capable of concentrating rolling stock for transportation purposes at any point on the sea board.

But what does Australia possess? A disjointed system of various gauges, indifferently equipped, and ungeographically subdivided for management, a system that is slow and costly for trade purposes, (as witness the disorganisation and congestion caused by a bountiful wheat season) and impossible from a military point of view. The break of gauge and State management prevents trade finding its proper geographical outlet, and hinders the development of the country, and in case of the invasion of any part of the sea-board, prevents the interchange and concentration of rolling stock for the transport of men and war material, and results in confusion and loss. The question of expediting the transmission of European mails accross the continent is at the present time occupying the attention of the Postmaster-General, and it is proposed, I understand, to sort the mails en route, but the break of gauge at Albury will make the transhipment of assorted mails a laborious and difficult task, and the gain in time will only be infinitesimal.

The only way in which the mails can be materially accelerated is to provide some means of allowing the mail train to run through to Sydney, such as laying a third rail on the main 5 ft. 3 in. track, to create another track of 4 ft. 8½ in., to let trains of the standard gauge run through. The mails could then be sorted in the same van in the run through, while upwards of twenty-seven hours would be saved in the journey from Adelaide to Queensland border. The journey now, including waits at Melbourne and Sydney, takes about sixty-seven hours, while with the third rail down it could be done in about forty hours. It is therefore more imperative to-day than ever it was before, that the unification of Australian railway gauges should be put in hand without delay, and that all the State systems should be Federated.

As engineers, we are more particularly interested in the first part of the problem, and as regards the break of gauge at Albury, we have seen many propositions put forward by practical and unpractical men for adapting the rolling stock to fit the different gauges. Hitherto it has been supposed impracticable to adapt the latter to carry the former, owing to the difficulty in fitting the points and switches in the confined space between the 4ft. 8½in. gauge and the 5ft. 3in. gauge; but latterly it has been demonstrated that the problem is quite easy of solution, and in a simple and inexpensive manner, by Brennan's switches and crossings for compound gauge railways, the drawings and models of which I am privileged to exhibit here this evening by permission of the inventor.

The apparatus is so exceedingly simple in design that we wonder that the idea has remained undiscovered so long, especially when so many have been searching diligently for some such solution of the problem. The switches, which are quite in keeping with well-known railway principles,

suitable for interlocking and use with standard gear, are a complete solution of the break of gauge difficulty so far as the 5ft. 3in. and the 4ft 8½in. gauges are concerned. The difficulty of bringing the trains alongside the railway platforms, which will occur when the platform is on the same side as the third rail, is overcome by laying down at the station a length of rail on the opposite side of the track to that on which the third rail usually lies; that is to say, the third rail will be shifted over to the opposite side of the track at such platform, and the trains of the standard gauge will run on to it and alongside the platform by means of a very simple device. It is apparent that the safety of the patent switches is absolutely assured by their simultaneous action, which so simplifies the signalman's work, that he need not trouble himself about the gauge of the trains he is handling.

I have purposely dwelt on these patent switches, as I wish to make it clear that the objection made in the past to the use of a third rail on the 5ft. 3in. track because of the supposed impossibility of switches to work the combined gauges no longer holds good, and that it will be as easy to work the 4ft. 8½in. and 5ft. 3in. gauges together as it is to work the standard gauge by itself. Moreover, there will not be the slightest difficulty in taking mixed gauges through, or make them form a temporary part of, any railway yard, or taking them to or away from any terminal station, no matter how complex the yard or the approach to a terminal station may be. The introduction of the third rail principle will certainly make for uniformity to the standard of the broad and standard gauges, for the change to the standard is the natural corollary of the third rail. So soon as sufficient rolling stock has been altered to 4ft. 8½in. to work any given section of the standard the outer 5ft. 3in. rail of the mixed track will be removed

and the standard gauge left remaining, while the 5ft. 3in. rail taken up will be used for an inside third rail on another section of the mixed gauge line.

Assuming that rails, &c., required for a third rail between Albury and Melbourne may be borrowed from stock, and returned to it later when the gauge is standardised, the actual cost will consist of labour in laying the third rail along a ready-made and sleepered track and the cost of shortening the axles of sufficient 5ft. 3in. rolling stock to work the standard gauge track, as also the cost of increasing the width of some of the platforms.

There are special features in the scheme of changing the 5ft. 3in. gauge to the standard by means of the third rail that must not be lost sight of, the more important of which is, that in the change from broad to the standard there will not be any disruption of the traffic; that the rolling stock may be altered at any place along the mixed gauge track, and when altered may be run out on the standard gauge and resume work at once, as part of the 4ft. 8½in. train. In fact, the change of the road and the rolling stock from the broad to the standard will take place so mechanically and evenly that no one outside the Department need be aware that the change is in progress.

A further feature that will weigh with those in authority is that in reducing the broad gauge to the 4ft. 8½in. there will not be any occasion to touch tunnels, cuttings, bridges, or viaducts; the only alteration in the road will be the increase in the width by 6½ inches of an occasional station on the side where the rails are close together.

I have given some study to this matter, and am satisfied that the only commercially possible way of establishing the standard gauge on the 5ft. 3in. road is by having recourse to a third rail.

With regard to the alteration of 5ft. 3in. rolling stock to 4ft. 8½in., it must be borne in mind that all the old stock will be worked out on the 5ft. 3in. compound track, as the altering of the gauge will extend over a series of years; that so much of the present 5ft. 3in. stock as may require to be altered to work any 4ft. 8½in. section may be economically altered, while all new stock that may be required in the natural order will, of course, be built to the standard gauge.

It is just a decade since my experienced and gifted predecessor in this Chair, Mr. C. O. Burge, M. Inst. C.E., drew attention to the question of unification of the gauges. At that date he realised that complete unification was only a happy dream, incapable then of practical realization. His view of the subject was, that with only 6½ inches between the gauges of Victoria and New South Wales there would be serious constructional objections to a mixed ga uge, andyet he is convinced that in the mixed gauge lies the best present solution of the question.

He further says, "When after Federation the traffic is absolutely unhampered by border duties, preferential rates, and unequal import duties, a third rail southwards from Albury to Melbourne will abolish the break of gauge as regards this large and increasing traffic."

He proposes to run the 4ft. 8½in. line round the back of the present stations, clear of all points so as to avoid the difficulty of running the mixed gauge through the points and crossings and interlocking gear of the larger gauge. He pointed out that as regards the cost of the work of complete unification it would be many years before the traffic reached such dimensions as to pay interest on the capital expended, but with a mixed gauge or partial unification between Albury and Melbourne (190 miles) the cost, including alteration to rolling stock, stations, and per-

manent way, would amount to half a million, the interest on which would be undoubtedly saved, by avoidance of the break. Since Mr. Burge wrote his address on the subject Mr. Brennan has found the "missing link," the cost of applying which is set down at from £60,000 to £70,000. The difficulties of handling traffic at Albury at present involve an outlay of about £1,500 (fifteen hundred pounds) per annum. This is the official estimate. If £60,000 or £70,000 is spent on laying down a third rail between Melbourne and Albury, and altering sufficient 5ft. 3in. stock to 4ft. 8½in. to work it, the yearly outlay in the way of interest in such an event will be very little more; while in the latter case, of course, we have the benefit of through standard trains for the same yearly payment.

The system referred to has been fully examined by competent authorities, and it may be claimed that a distinct advance has been made in the past two years towards the fulfilment of Mr. Burge's prediction, as outlined above.

As there are three gauges in existence, viz., 3ft. 6in. in Queensland and West Australia, 4ft. 8½in. in New South Wales, and 5ft. 3in. in Victoria, whilst South Australia has 5ft. 3in. for its principal system and 3ft. 6in. for the Northern Territory, the question is certain to arise, what shall be the universal gauge. Each State will want its own gauge to be the universal one. The New South Wales 4ft. 8½in. gauge has a mileage of 3,728, Victoria and South Australia 5ft. 3in. have combined 3,901 miles, and Queensland, the Northern Territory of South Australia, and West Australia 3ft. 6in. have combined 6,160 miles, and judged by the question of mileage, it would seem unreasonable that the universal gauge, of which there are fewest miles open, should be 4ft. 8½in.

But the material facts governing the policy of conversion may be other than that of mere mileage, and would rather

embrace such considerations as those of the proportionate costs of alteration to road and rolling stock, and the question of carrying capacity and speed, which come entirely within the sphere of the engineer to decide. The first thing will be to get rid of all extraneous questions of local or State policy by placing the railways under Federal control, and then the engineer can tackle the problem and solve it on the most economical lines.

The coal trade from our western coalfields has always been very seriously handicapped by the want of trucks, and this is of so serious a nature when wheat and wool are coming forward that the permanent building of an oversea trade has been frequently frustrated; if the concentration of idle trucks from other States were possible it would mean the development of an industry and the increase of Australian exports.

The question of the unification of the gauges when regarded through State spectacles has always been declared impossible, but so far as I am aware it has never received unbiassed consideration.

In addition to the conversion of the gauges of lines already built, there is the question of strategic railways looming close upon the horizon. At present Western Australia is isolated from the rest of the Commonwealth, and is specially liable, in the absence of the British Navy, to attack from a foreign foe. The Northern Territory and northern parts of Queensland, containing about a million square miles of tropical country, are practically uninhabited, so far as the white man is concerned, and is the open door to Asiatic hordes north of Australia. One hears rumours of an incipient invasion of these undesirables having already set in, so the need of strategic railways for the combined purposes of settlement and defence, is a very pressing one. A glance at the map of Australia exhibited

on the screen will show that the railways of Western Australia are entirely disconnected from the eastern States, and that the railways of Northern Queensland are isolated branches, and disconnected from the southern system connecting with the southern States.

For strategic purposes, and for linking up the whole continent, it will be necessary to construct:—

1. A main trunk line from Kanowna to Port Augusta, or from Kanowna to Oodnadatta, as proposed by Sir John Forrest.
2. To connect the northern and southern systems of South Australia by constructing a main trunk line from Oodnadatta to Pine Creek.
3. To connect the South Australia system with the northern system of Queensland by constructing a line from Oodnadatta to Blackall and Barcaldine, connecting up Barcaldine and Winton.
4. To connect the Townsville and Hughenden line with the Normanton to Croydon and the Cairns to Croydon line.
5. To construct a line westward from Normanton along the southern littoral of the Gulf of Carpentaria, to join the Northern Territory main trunk line at Daly Waters.
6. To construct a line north from Croydon or Normanton along the eastern littoral of the Gulf of Carpentaria towards Cape York and Thursday Island.
7. To extend the New South Wales system beyond Bourke to connect with the proposed line Oodnadatta to Blackall.

In classing these lines as strategic, it must be understood that the application of the title is intended to cover both military and developmental purposes. The development

and settlement of the Northern Territory may be said to be the most difficult of all Australian problems, and the first step towards the solution must be the construction of the railway first mentioned. That it will pay to develop is the opinion of many competent observers; it is richer in gold, silver, copper, tin and lead, than any other part of Australia; it has a magnificent harbour in Port Darwin, only second to Sydney as a port, backed up by the finest pastoral country in the world. Its capabilities are fully set forth in the report on the Land Grant Railway issued by the South Australian Government in 1902.

Therein the explorers John McDouall Stuart (1861), Ernest Giles, J. A. Giles, Ernest Favenc, Alfred Giles, Simpson Newland, Charles Winnecke, F.R.G.S., David Lindsay, W. H. Tietkens, F.R.G.S., Captain Stokes, R.N., David J. Gordon, H. G. L. Brown, F.G.S., Government Geologist, Rev. J. E. Tenison-Woods and many others speak of its wonderful resources for wool growing, cattle raising, and its great wealth of minerals, and I commend this publication to the perusal of all those interested in the development of Australia.

The report by Captain Cresswell, R.N., in the proposal to establish Indian Government Horse Depôts in the Northern Territory for breeding and training remounts for the Indian army clearly shows that the Northern Territory is a magnificent breeding ground for horses, and one that could be made a source of supply for the whole Empire. At the present moment we have the facts staring us in the face, that ordinary farm horses are from £40 to £60 a head, and on account of the scarcity we are reverting to the use of the bullock for traction purposes, and yet we have vast areas lying idle, capable of supplying not only our needs but those of the whole Empire.

The Hon. W. McCourt in a very interesting article in the *S. M. Herald*, 30th April, has drawn public attention to the

necessity for connecting up this State with the proposed line to Port Darwin for trade purposes, and the proposition is one of great value, as giving Sydney access to a port which could be made a terminal port for all mail services direct from Europe, viâ the Suez Canal, during war time and in the event of the southern coasts being blockaded, or in the event of Great Britain losing the command of the Suez Canal, viâ Vladivostock and the Siberian Railway. The sugar growing industry which already gives a substantial amount to Australian wealth, is capable of enormous development in these tropical areas, with the aid of suitable labour under proper control and with railways. These are the problems, you as engineers, will have to deal with some day, and until they are settled our possession of Australia cannot be said to be either permanent or safe.

In connection with the construction of railways such as are here indicated, most of them passing through dry country, the problem of water supply will be encountered, but here again the trained intellect of the engineer will be required to overcome the difficulty.

The relation of electricity to land development was pointed out by Mr. Thomas Rooke, Assoc. M. Inst. C.E., in papers read before this Society in 1903 and 1904, and the possibility of the transmission of electricity over great distances was discussed in regard to power distribution. He stated, that in America, development of territory was being carried out on a very extensive scale, electrical lines distributing power for many purposes. Electricity is there transmitted over distances more than two hundred miles, an area of 140,000 square miles of territory being commanded by one power house, and longer and larger transmissions are being contemplated. As regards the source of power, Mr. Rooke showed that coal was more economical than water, even where the latter was present

in abundance. Here water is scarce, but coal is everywhere abundant, and if the developments of electricity are to proceed as rapidly in the future as they have done in the past, its application to railway purposes must come very soon. Everything is favourable to the production of electricity in Australia; we have extensive coalfields right through our large and unoccupied areas; generally the coal is very near the surface, and of excellent quality, and there is no reason why the employment of electricity should not solve the problem of operating railways through dry country.

The enormous developments of the future that I have here outlined only in one direction will create an unprecedented demand for engineers, and as the condition of the work will be entirely Australian, and will probably develop along entirely original lines, the opportunity will be unique for creating a distinct type of Australian engineering. But if the young Australian is going to avail himself of these chances and to take what belongs to him in virtue of his hereditary rights, he will have to abandon the characteristic Australian trait of leaning against a post, whether the said post be the Government or any eleemosynary support.

Local Government in New South Wales, although primarily a State question, is one of such magnitude, that it may be regarded as an Australian problem. By the passing of the Shires Act an important piece of decentralisation has been effected, and the engineers, who formerly were Government officers, now become municipal engineers. This sudden change will have far-reaching effects upon the status and qualifications of the shire engineer, and in order to fill his position satisfactorily to the shire he will have to be a man of all-round capabilities, qualified to deal in its entirety with every phase of engineering that may present itself in his district. He must be prepared to take the full responsibility of all works without a department at his

back to protect him under the ægis of infallibility. The result will be that the occupier of the position of shire engineer must rise from being a mere officer of a bureau to the full and higher status of a responsible engineer.

Apropos of this question, it will be interesting to note that the Institution of Civil Engineers, Westminster, has just completed an elaborate enquiry into the training of engineers, the results of which are published in the last volume of the Proceedings, and which should be studied by all engineers who take an interest in the welfare of their profession. The professional status of the municipal engineer was considered in 1904 by the Incorporated Association of Municipal and County Engineers of Great Britain, and the conclusion arrived at was, that the positions of engineers and surveyors to all local authorities should be given only to those who are possessed of the necessary qualifications and experience, and that all such appointments should be made subject to the confirmation of the Local Government Board.

It is satisfactory to note that the representations which were made by the united bodies of engineers of this State at the invitation of this Section, on the question of qualifications of engineers, have received recognition by the Government, and that our recommendations in their entirety are included in the regulations applying to shires and municipalities.

The establishment of Local Government is one of the problems that has been vexing us for the past thirty-five years, but at last it has made its appearance in the Statute Book; this does not mean that the problem is solved and done with; very far from it. The solution has yet to be worked out, and its successful accomplishment rests very largely upon the shoulders of engineers.

The permanent and successful establishment of Local Government will mean the evolution and development of municipal engineering, creating a demand for the services of trained civil engineers. It is therefore clearly the duty of the profession to see that only fully competent men are admitted to its ranks, and at the same time to take such steps as may be necessary for defining from time to time the qualifications necessary for admittance. Unfortunately the civil engineers of this State are like sheep without a shepherd, in that they have no institution to govern, direct and represent them. It is true that the great parent institution of civil engineers is represented here by a local board, but that board only looks after the local interests of the institution in Great Britain ; it is not representative of Australian engineers, and is absolutely of no use to them. This Section, of which we are proud to be members, is only of service to engineers on scientific grounds, but otherwise of little value as a representative institution.

It is high time we had a purely Australian institution, affiliated, if you like, with the parent institution, but one the governing body of which should be elected by, and responsible to, Australian engineers.

Engineering and Municipal Services.—The range of municipal activity is extremely circumscribed in New South Wales, and there are many services at present divorced from municipal control, which should be included in order that citizens may obtain the full benefit of municipal institutions. The transfer of these services which are essentially municipal to the control of the municipality, is one of the problems of public life confronting us to-day in this State which demands consideration and solution. Amongst the services I refer to may be mentioned water and sewerage, tramway and fire-services, all of which, both for construction and maintenance, should be in the

hands of the municipality. I do not wish to detract from any merit the authorities now controlling these services are justly entitled to, for the way in which those services have been constructed and maintained, for they have done exceedingly well, but I am contending for the great principle of popular control of domestic services as against that of bureaucratic. The concentration of all these services under municipal government where they rightly belong, would result in economy, and any profit arising therefrom could be allocated to improving the city, removing slum areas, beautifying the parks, and maintaining the streets; as regards the latter, it does seem unjust to the ratepayers that they should be called upon to maintain streets which are constantly being cut up for the repairs of services, which bring in no revenue to the municipal coffers, and over which the municipality has no control. Apart from that, the municipality should only be deprived of its streets by the central government in time of great crisis.

Our domestic services of water supply and sewerage are subject to all the evils of dual control, which is not only the cause of much friction between State and municipal officers, and waste of time and money, but has the direct effect of removing the responsibility from the officers' shoulders charged with the control and management of these important services. If the charges for these services were to be defrayed from the general taxes then there would be some justification for the Government executing the work; but the moneys are borrowed by the municipality, and rates are levied on the ratepayers to pay the interest and redemption of the loan, so that the general taxpayer does not contribute, and has no interests to be conserved. If the people are to be trusted with municipal government they should be trusted up to the hilt to carry

out their own works, subject to the approval of the Local Government Board (as in Great Britain), and the due payment of the interest. If the existing loans on these services were converted into debentures, guaranteed by the Government, they would become a very popular form of investment, and the Government would be under no risks except such as could be provided for by power to appoint a receiver in case of default.

During my recent visits to New Zealand I took the opportunity of studying municipal life there, and I found it much broader and more comprehensive in scope and aim than anywhere in Australia. There the tramways, electric light and power, gasworks, water and sewerage, public parks and gardens, besides other services, are all constructed by and under the control of the municipality. The organisation of all municipal services, including those I have mentioned, as properly belonging to the municipality, is the duty of the municipal engineer, and is one of the problems Australian engineers of the future will be called upon to deal with when the higher municipal life is reached.

A brief glance at the duties of a modern municipal engineer will reveal the extreme complexity of his duties. They embrace the construction and maintenance of streets, tramways, electric lighting and power works, water supply, sewerage and sewage treatment, gasworks, sanitation of streets and dwellings, collection of garbage and the construction of garbage destructors, the organisation of fire-fighting appliances, the building of markets, abattoirs, fire stations, or perhaps, even a town hall. The carrying out of such duties requires a master mind for directing and controlling a large staff of skilled assistants, and a broad capacity for dealing with every phase of engineering, and involves years of preparation of the highest training. But

the inducement here offered to the engineer with such a wide scope of municipal activities constitutes a career worthy of the greatest intellects or attainments.

When municipal councils rise to the conception of their true position in the economy of Australian life, when they have learned to act and stand alone, independently of the Government, when they have reached such a state of maturity that they will seek to have control of the services I have indicated, then the demand for engineers will be ever increasing, and our University will be full of students preparing themselves for future duties in their own land, instead of drifting away, after graduating, to such out-of-the-way places as the Malay States.

We have magnificent material in the intellect of our Australian youths for training into high-class engineers, we have a splendidly endowed University capable of affording that training; in fact every facility for producing Australian-born engineers, and yet, owing to the limited sphere and lack of inducement, how few young Australians adopt civil engineering as their profession. In the near future, as already pointed out, Australia will need many engineers for the proper development of its huge territory, and for the solution of other Australian problems. Where are they to come from? Are we to train our own men, or are we to continue importing from abroad?

The Problem of a Greater Sydney is still before us under the modern and inept cognomen of city extension. "The Sydney Municipalities Consolidation" would better express the nature of the work to be done. Efficiency and economy both demand some change from the present system, and the time for pause has long since passed away. In view of the plague having established itself firmly within our borders, any further delay will be dangerous to our well

being, both from a sanitary and commercial standpoint. The division of authority now existing between the many municipalities, the Harbour Trust, the Water and Sewerage Board, and the Public Works Department, makes any attempts to stamp out the disease perfectly futile. What is wanted is a consolidated municipal authority with extended powers. Any form of municipal government which nominally gives power to the municipality, but which in reality leaves it in the hands of the Government is of no use; the people must be trusted absolutely with their own domestic affairs. Why cannot our civic government be based upon the experience of British and Continental cities? When a change is made, we have a splendid opportunity to adopt what is good and to avoid what is bad. The phenomenal growth of the city is only intensifying the difficulty of solving the problem, and the longer the delay the greater will be the multiplication of difficulties. Enlightened citizens are unanimous in condemning the present muddling, and demand a powerful consolidated municipal government.

The engineers of Sydney, so far, have not been heard on this question, although their special knowledge and high intelligence would entitle them to speak with authority. A faint protest has arisen on a few occasions from the architects, but no combined expression of opinion has even been enunciated. The public are waiting for and would welcome an expression of the views of the allied professions of engineers, architects, and surveyors, and I feel sure that the necessity for some such patriotic and self-denying work on their part needs only to be pointed out to be immediately acted upon.

In close connection with the problem of municipal consolidation is that of the beautifying of our streets and public places, not only in Sydney, but in all our country

towns, although I am happy to assert that in respect of the public gardens, the country towns in some instances lead the way. I was greatly struck, when spending a few months lately in New Zealand, with their ideas of street ornamentation and beautification by means of flowers and shrubs. Any odd corner of vacant land or impracticable street is there converted into a spot of beauty and a delight to the eye with beautiful flower gardens; the flowers being generally chosen for their brilliancy of colouring, so as to relieve the dinginess of the surroundings. Nearly all our streets and public places are harsh and unlovely, the atmosphere is polluted with the outpourings from many chimneys of enormous volumes of sooty smoke, our thoroughfares and footpaths are dirty and unkempt, clouds of dust sweep through them, and the eyes and senses are harassed where otherwise they might be charmed and rested by congenial surroundings.

In all Australian towns it must be admitted that there is room for improvement to make life safer, pleasanter and happier. The poorer parts of these towns from which the dwellers are unable to get away to seaside or mountain resorts, and in which they have to spend all their lives, should be first attended to, by securing to them clean and healthy surroundings, and giving them a few beauty spots to gaze upon.

As regards the sanitation of country towns, we all know of the discomforts attending a visit to a country town by those used to the sanitary conveniences of the city, and the feelings of horror and disgust engendered by the sudden change; and yet, thousands of our fellow countrymen, with their wives and children, daily run the gauntlet of typhoid, diphtheria, and enteritis, quite regardless of the teaching of modern sanitary science.

It has been admitted that the question is a difficult one from a financial point of view, but here again the engineer has an opportunity of solving the problem of bringing the sewering of country towns within the perimeter of practical politics and practical municipal finance. In this connection engineers want to study systems more suitable for the low-lying and flat areas upon which our country towns are built, in order to dispense with the costly and heavy works entailed by the adherence to gravity methods.

The subject chosen for my discourse would be incomplete without some reference to the problem of irrigation and water conservation, which, notwithstanding all that has been said and written about it, in this Section and elsewhere, is still a problem unsolved. When viewed in the light of development of the Australian continent it assumes a greater magnitude than ever, and to the mind of the engineer, is one of intense fascination. The start now being made at Barren Jack is the first step in the march of conservation progress, and should be watched in New South Wales with the same solicitude that a young mother watches her infant's first attempt at walking, in order that no initial mistake will mar its future progress. Neither time nor inclination will permit me to dilate further on a well-worn subject, except to remark that its successful prosecution will still further develop engineering in Australia.

In conclusion, there are, doubtless, other problems for engineers to solve in Australia. The municipal, mining, and marine engineer, each in his different sphere, has various obstacles to overcome, and activities to develop. But I venture to think that I have touched upon what are more or less pressing.

To the empire builder, the statesman, the patriot, the politician, the economist, and the student of history these

diagrams in black and white—object lessons, so to speak—will most assuredly appeal, and if I succeed only in a small degree in attracting public attention to the necessity of grappling with the problems presented, my all too lengthy address will not have been in vain.

PUMPING MACHINERY OF THE METROPOLITAN BOARD OF WATER SUPPLY AND SEWERAGE, SYDNEY.

By J. F. FURNISS.

[Paper, illustrated by lantern slides, read before the Engineering Section of the Royal Society of N. S. Wales, 18th September, 1907.]

IN all great cities the water supply and sewerage services form a very important feature from an engineering standpoint, Sydney being no exception in this respect, being in fact in the forefront, with an ever increasing demand for extension, due to a phenomenal growth of population, and, to keep abreast of the times, its engineers have, in many instances, made specialities of all that important necessary knowledge, attainable only by contact and experience with works in actual operation.

In water supply and sewerage pumping requirements, the intermittent nature of the work always detracts from those high records of efficiency produced on trials; hence the necessity of making provision, as far as possible, for a series of pumps, running some only of the series at the fullest efficient speed up to their limit, and placing others in operation when needed. Some types of engines and installations lend themselves to this procedure; others do not.

In this State there have been a fair number of installations during the past thirty years to guide us in the selection of the fittest, and to provide a study of the various good qualities which might be availed of in the adoption of the best of these.

There was the old Botany plant which served this city many years ago. This is an example of the old beam type of pumping engine, now practically gone out of use. Crown Street Pumping Station has passed along the various stages from horizontal direct acting rotative engines, supplemented by Blake's pumps, to the most remarkable engine at the date of installation ever introduced into the colonies, viz., the direct acting non-rotative Worthington engine, connected up to Babcock and Wilcox boilers, also the first of their kind in this State. Supplementing these is now the high duty centrifugal connected to an electric motor of 700 H.P. Another station, Ryde, has a good type of old style pumping engine lately supplemented by turbo pumps connected to the latest type Stirling boilers.

Marrickville Sewerage and Stormwater Station has two pairs of differential direct acting compound pumping engines of the Hathorn-Davey type, whose peculiar feature is somewhat allied to the Worthington, in so far as provision is made to store energy at the beginning of the stroke. While on the question of economy, it must be remembered that an economical plant includes the whole of the stages, from the handling of coal at the point of supply to the station, right through the final one of the disposal of the ashes and waste in other directions, after the whole of the available temperature has been economically utilized, not forgetting that much waste is caused by the want of appliances essential to this end, and, in many cases, by the want of vigilance or the necessary interest in these matters to guard against losses in this particular. Hence the

efficiency that was obtained in the trials or at the inception of the installation of a plant, is gradually reduced.

Electrically driven pumps are specially suited to cases where a considerable number of pumps scattered over a large area are under one control. Centrifugal pumps lend themselves to this class of work, but the consideration of the question of their efficiency being only as, say 62 to 75%, they are rejected, although experience has proved that in the space of a few years the pump with the highest efficiency has virtually become obsolete by the process of attrition. Of course this process will go on in the case of the centrifugal type, but the question of renewal of a pump case or impeller is an easier and less costly matter than renewals of pump barrels, plungers, etc., especially in inaccessible places.

Centrifugal Pumps—Efficiency and Applicability.—*Single Stage, low heads.*—The highest efficiency that has been obtained by these pumps in actual work is 62%, and this only when the impeller and case are in good condition and a perfect fit. The running conditions require close watching, otherwise great loss may occur. Notwithstanding the low efficiency of centrifugal pumps, they have been found especially useful in some services, and in a calculation based on low initial cost compared with other types, they may be considered worthy of adoption, although a difference of 30% efficiency in favour of the other types, would certainly represent a lot of money annually extended over the life of the respective types.

Excellent results have been obtained with the Reynolds' form of pump, a view of which is shown in fig. 1. This was the first pump introduced to this State; it is capable of raising a large volume of water to a great height, viz., four million gallons to 240 ft. head in 24 hours.

Following this was the pump recently erected at Ryde, but which was imported in 1903, hence lacking the more recent improvements, the period of four years from 1903 to 1907 having been the most remarkable in the introduction of such improvements in the history of this class of machinery. During this time steam consumption has been reduced from 36 lbs. to say 22 lbs. per HP. per hour. Hence a considerable gain will accrue to more modern installations. As an instance of what can be done in America, they have produced a five series, side by side, centrifugal pump, the capacity of which equals thirteen million gallons per day to a head of 430 feet.

The question of the size and position of the air vessel on suction and delivery pipes is one which is intimately connected with the success or failure of a pumping plant and it is always best to err on the side of large capacity than to run the risk of a deficiency in these auxiliaries to effective working. Constructors of centrifugal pumps appear to have treated the question of end-thrust in a lax manner, some even going so far as to state that it does not exist, nevertheless they make some provision by the addition of thrust rings on the impeller shaft generally quite inadequate for the requirements; when the pumps are electrically driven, some makers depend upon what they term magnetic pull to counteract thrust, but such provision fails, especially during that period necessary to charge the pump and rising main, as it will be readily understood that until a constant load is on the pump variable conditions prevail as regards the power absorbed by it. The only safe provision is thrust surface large enough to provide for this which need not add to the friction, it being so adjusted that at constant load it would be virtually inoperative. Many appliances such as ball race, friction rings and ordinary marine type thrust blocks have been used, but none, in the author's opinion,

have been so successful in large plants as the balance piston type, operated by fluid pressure similar to the footstep block adopted by the vertical turbine generator makers.

Based upon the author's experience, he draws the following conclusions:(1) That the triple expansion direct acting rotative pumping engine with all latest improvements adopted has brought the steam consumption per HP. per hour down to the lowest point. (2) The direct acting nonrotative high duty pumping engine is next in order for economy of consumption, but has advantages which the first does not possess, viz.: longer life, less cost in up-keep and a steady flow of fluid pumped. (3) The steam driven centrifugal pump is next in order for large installations. (4) That electrically driven pumps in large installations can never produce work so economically as steam until electricity is much cheaper in cost as the following shows:

Fuel cost per HP. per annum coal at 10/- per ton £5 2s min. £19 11s. max.

Present cost of electricity per annum per HP. £36.

The author has collected some data as to steam used per HP. per hour and piston speed in feet per minute as under:

Efficiency.	Press. Feed.	Piston Speed.	Steam per HP. p. h.
Water works, Copenhagen		159·8 ft.	22·7 lbs.
Hampton, marine type		297 ,,	15·9 ,,
Liverpool, triple type		203 ,,	14·2 ,,
Nordberg, American	215 lbs. 311 ft.		12·26,,
Old Botany Beam type			30·0 ,,
92% Crown-st. Worthington		144 ,,	22·0 ,,
85% Marrickville Hathorn-Davey		108 ,,	24·0 ,,
90% Ryde Compound Rotative		144 ,,	21·0 ,,
92% Spottiswoode Hathorn-Davey		171·9,,	13·0 ,,

The paper was illustrated by numerous lantern slides of which some are reprduced:—

Fig. 1. High lift centrifugal pumping engine at Crown Street Pumping Station consisting of a Gwynne single pump and a Reynolds' pump likewise single stage connected to an electric motor.

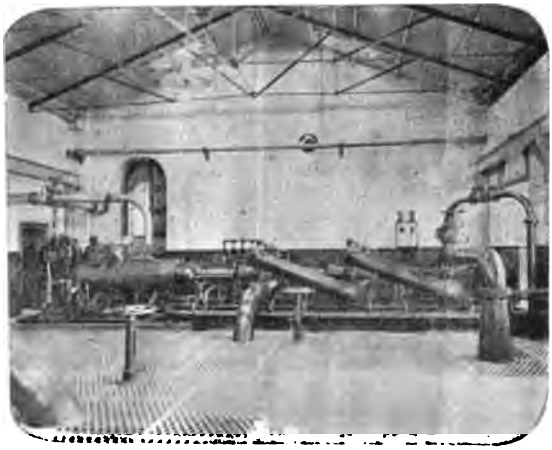


Fig. 2. Turbine driven centrifugal pump making 3,000 revolutions per minute and raising water to a height of 240 feet. This pump is described in Vol. CLIV., Proc. Inst. C.E., Engineering Conference, in a paper read by Mr. Cecil Darley, M. Inst. C.E., I.S.O.

Fig. 3. View in the Boiler House at Ryde of the coal bunkers and firing arrangements.

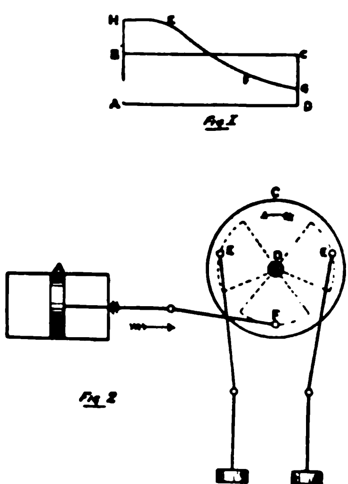


Fig. 4. Diagram of the principle upon which the Hathorn-Davey pumping engines at Marrickville are constructed.

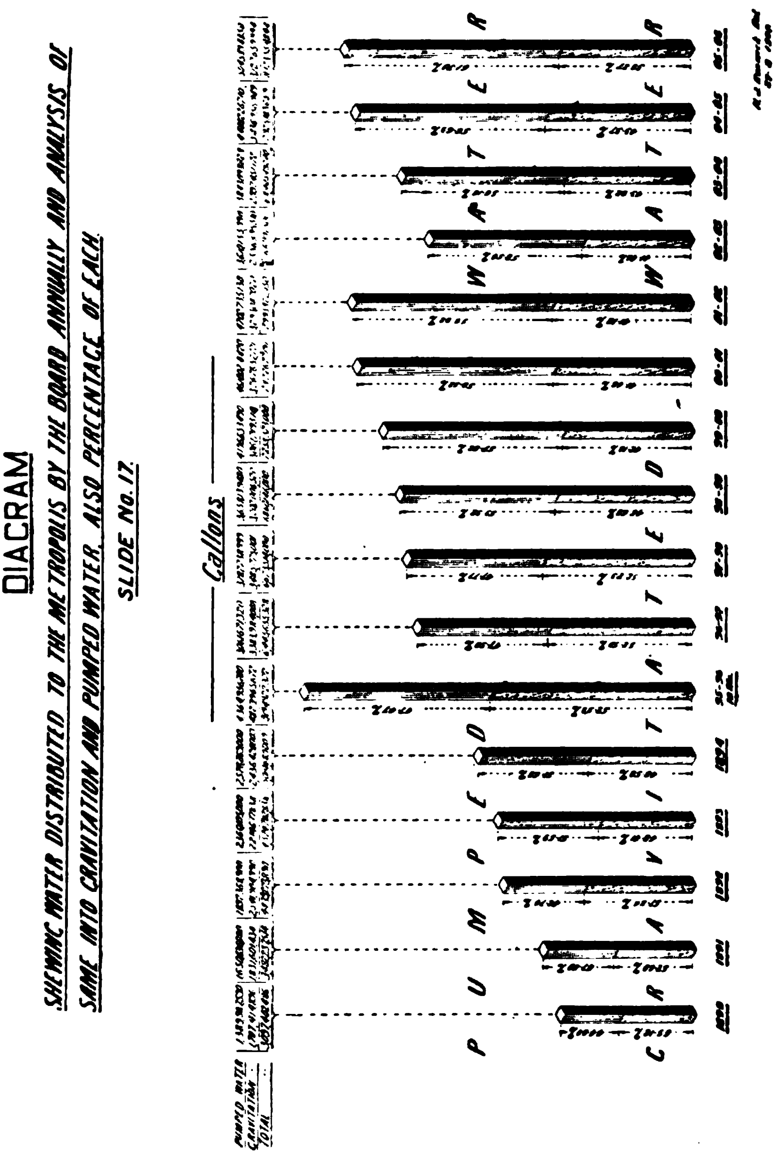


Fig. 5. Shows the percentage of water pumped, to that supplied by gravity, from the year 1890 to 1906, by the Metropolitan Board of Water Supply and Sewerage.

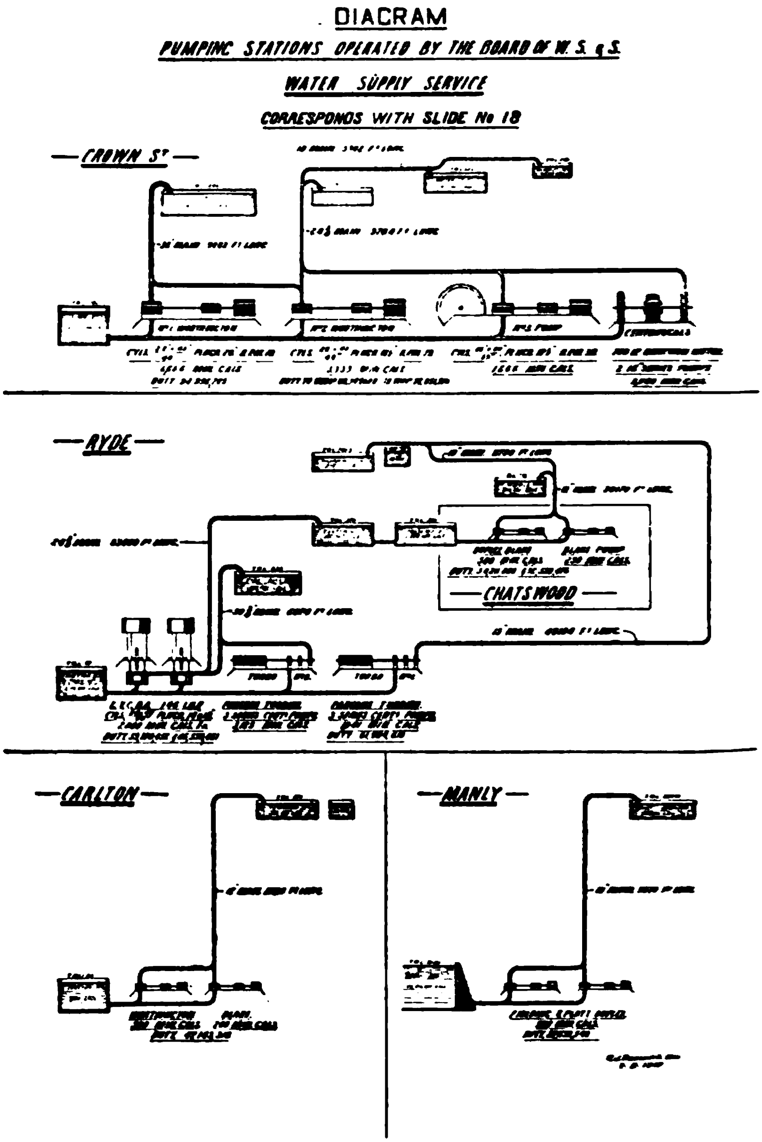


Fig. 6. Diagram of the Pumping Stations in connection with the water supply service of Sydney.

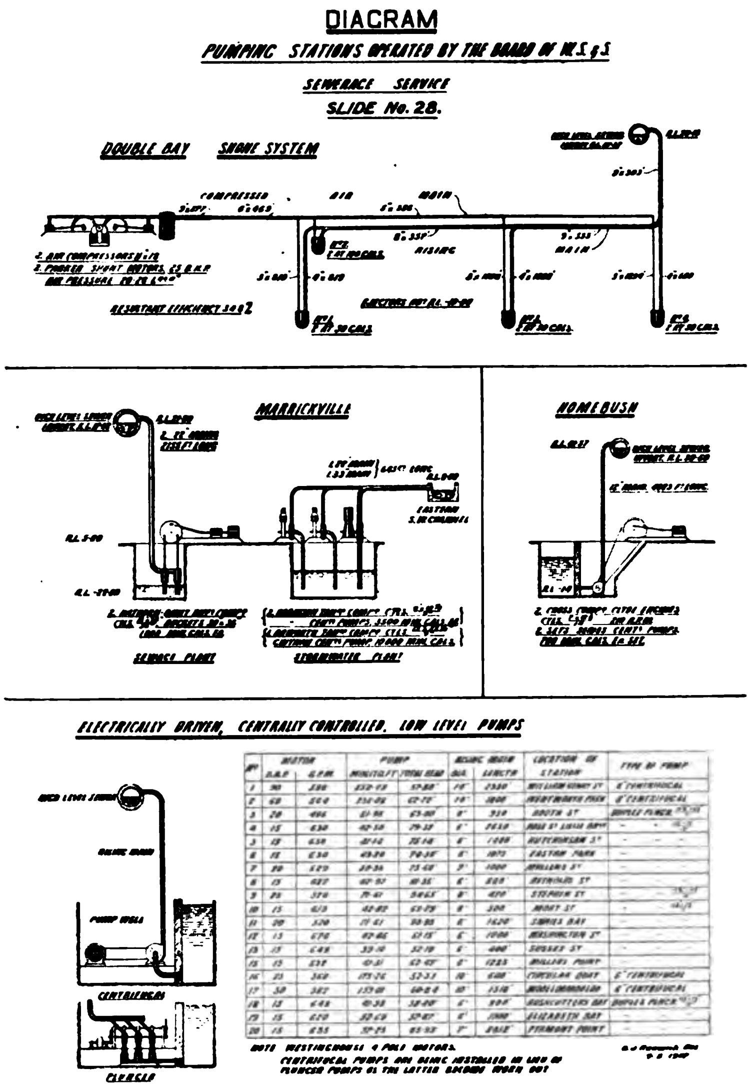


Fig. 7. Shows the various systems adopted for raising sewage, from the low level sewers to the high level now under the charge of the Metropolitan Board.

SLIDE No. 33.

MARRICKVILLE LOW LEVEL PUMPING ENGINES

RESULTS OF DUTY TRIALS MADE ON JULY 19th & 24th 1900

HATHORNE DAVEY DIFFERENTIAL COMPOUND

CYLINDERS $\frac{15" \& 30"}{36"}$ BUCKETS 30" × 36" stroke

Data from Readings taken every 15 minutes	"B" Engine. July 19th	"A" Engine. July 24th
Duration of Trial	12 Hours	12 Hours
Total Number of Revolutions	10,910	10,593
Average " " per minute	15·15	14·71
Indicated Horse Power, High Pressure Cylinder	25·704	22·39
" " " Low "	20·107	20·35
Total Indicated Horse Power of Engine	45·811	42·74
Total Head in feet, including Friction	41·34	40·88
Weight allowed per Cubic Foot of Sewage	63·50 lbs.	63·50 lbs.
Capacity of Pump Plungers per Revolution	29·45 Cubic feet	29·45 Cubic feet
Work done by " " "	77,315·46 Foot Pounds	76,473·85 Foot Pounds
" " " " in 12 hours	843,511,681 "	810,087,306 "
Pump Horse Power	35·5	34·1
Water from Hot Well in 12 hours	12,897 Pounds	14,618 Pounds
" " Jackets	1,837 "	1,857 "
" " Economiser Engine in 12 hours	480 "	480 "
" " Leaks in 12 hours (say)	150 "	150 "
Total Water Evaporated	15,364 "	17,085 "
Total Steam Consumption	14,734 "	16,455 "
Steam Consumption per Pump Horse Power Hour	34·50 "	40·21 "
Total Coal consumed in 12 hours	1,500 "	1,456 "
Water evaporated per pound of Coal	9·79 "	11·73 "
Efficiency of Mechanism	77 %	79 %
Duty in Foot Pounds per 112 lbs. of Coal	59,250,034	62,314,426
Coal Consumed per Indicated Horse Power Hour	2·85 Pounds	2·83 Pounds

Fig. 8. Gives some details of tests made by the author on the Hathorn Davey engines at Marrickville.

CITY LOW LEVEL PUMPS

EFFICIENCY TESTS

Plunger Pump driven by Motor by Double Reduction Spur Gearing
Centrifugal - - - - - Leather Belting

SLIDE No. 35.

Type of Pump	Minute Pounds	Head in Feet by Gauge	Height of Gauge above Mean Level	Total Average Lift	Time of Run in Minutes	Total Watts Used	Pump Horse Power	Electric Horse Power	Combined Efficiency	Pump Efficiency	Remarks
Differential Plunger (Triple)	8793.7	48.3	4.97	53.27	6.75	31,800	14.14	37.80	37.40%	75.16%	Discarded
Centrifugal 6" (Imported)	6269.9	50.82	4.97	55.79	9.583	39,000	10.59	32.75	32.35%	48.53%	
Centrifugal 8" (Local Manufacture)	14755	62.37	4.97	67.34	4.00	50,000	27.88	60.32	46.21%	60.40%	This Type of Pump adopted by the Board
Centrifugal 6" (Local Manufacture)	10960.8	46.00	0.00	46.00	4.25	25,650	15.27	30.76	49%	58.40%	
Centrifugal 6" (Local Manufacture)	9938	55.20	0.00	55.20	3.75	25,500	16.62	34.18	48.62%	57.20%	

Note. For Centrifugal Pumps the Motor Efficiency is taken as 85%
" " " Belt Drive " " " " 90%

Fig. 9. Gives calculated pump efficiencies of the City low level sewerage pumps.

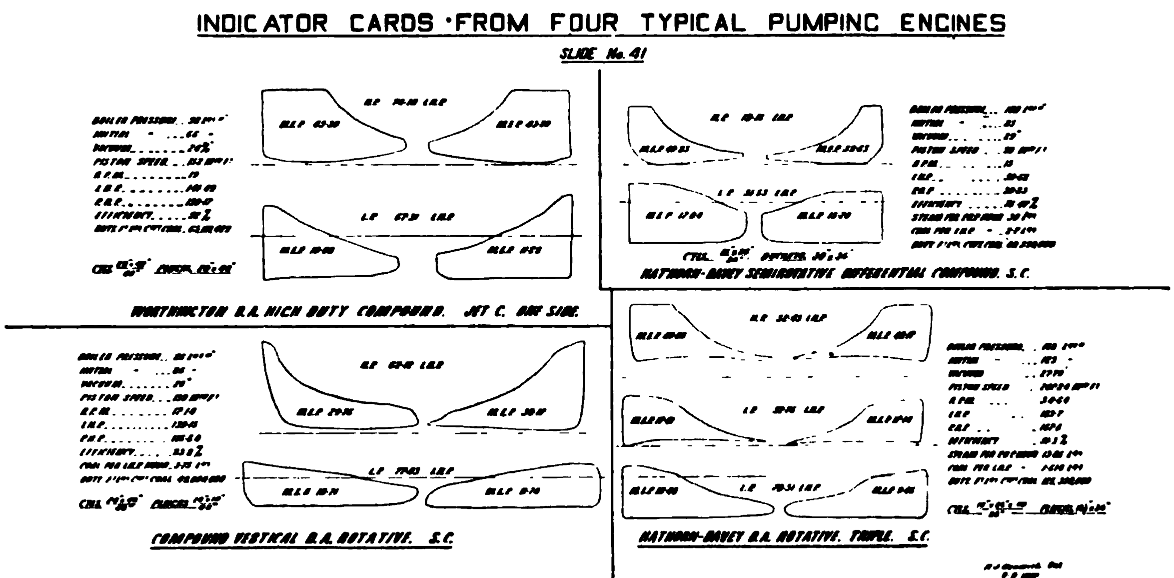


Fig. 10. Is a set of indicated cards taken from the temporary pumping plant at Menangle. This engine drove an electric generator which supplied the current for a motor connected to the Reynolds centrifugal pump shown in Fig. 1.

Discussion.—The President, Mr. T. W. KEELE, M. Inst. C.E., introducing the discussion, said:—The business of the evening, gentlemen, is the discussion of Mr. Furniss's paper on the Pumping Machinery of the Metropolitan Board of Water Supply and Sewerage, which was read by the author at our meeting held on Wednesday, November 20th, 1907. He then called on Mr. Norman Selfe.

Mr. NORMAN SELFE, M Inst. C.E., said:—The paper of Mr. Furniss was of great interest if considered only as an addition to the "Records" connected with the Water Supply of Sydney; but the author was also to be complimented upon the extent of the data which he had accumulated, and the very interesting series of lantern slides exhibited, some of which (as the old Botany pumping engines) are of historical value. As the early history of the water supply of Sydney has not yet been fully written, it might be opportune now to record the fact that the first steam pumping engine employed for that service was set up in the forties during the time that Daniel Egan was mayor of the city under the original corporation. This machinery was erected at the site where the Randwick road crosses the main stream to Botany, and was employed to raise the water otherwise running into Botany Bay up into an elevated tank, whence it flowed to the Lachlan Swamps, in order to augment the supply to the "Tunnel" or Busby Bore. After the Botany engines came into use the old engine was sold, and he (Mr. Selfe) adapted it to the ferry steamer "Quandong," in which vessel it worked for many years until broken up.

Coming to the technical portion of the paper several of the statements therein were not precisely correct, or at any rate were calculated to convey a wrong impression. For instance, in the second paragraph it is said—"The intermittent nature of pumping work detracts from the

high efficiency of trials." Now the efficiency of a steam pump is only gauged by a comparison of the fuel or steam used with the results obtained therefrom in a continuous trial of longer or shorter duration. If the pumps are running eight hours and standing sixteen out of the twenty-four afterwards in their actual daily work, and as much coal is used in those sixteen hours by banked fires or otherwise as is consumed in the eight hours work (such things have been reported), that surely is no discredit to the engine's efficiency. Certain it is that no class of engines run with a more uniform load than pumping engines, or afford better opportunities for the adjustment of the steam pressure and grades of expansion necessary to secure the most economic consumption of steam.

In the fifth paragraph of the paper it is stated that the Hathorn-Davey differential type is allied to the Worthington (High Duty) "in so far as provision is made to store energy at the beginning of the stroke." Now without being captious or hypercritical it must be pointed out that the two systems are entirely and essentially different in their methods of providing constant pressure to overcome constant resistance. The Worthington high duty pump does store energy when the pressure on the steam piston is above the mean required by the pump, but instead of storing it in a fly-wheel as a rotative engine does, it stores it in an air-vessel. And here it may be said that so far no accurate investigations appear to have been instituted, and the results of such made available, to show the relative percentage of the total energy developed which is lost under the two systems. In the Hathorn Davey differential system there is no storage of energy except in the inertia of the reciprocating parts common to all engines; but, instead of there being a constant relation and correspondence between the velocity of the steam and water pistons, as in the direct

acting and rotative systems, there is not only a continually varying ratio between the speeds of the steam and water pistons but the mean speed per minute of the two ends is not necessarily the same. Theoretically the Hathorn Davey differential system should be expected to give the best results, and if the record of the Spottiswoode engine is absolutely reliable, then it would seem to be borne out in practice with a consumption of 13lbs. of steam per HP hour; but if the Marrickville outfit of same type takes 24 lbs. of steam as stated, there is certainly an opening for further explanation in the author's reply.[1] The duty recorded by the trials at Marrickville of July 1900, are no better than those of the old Crown-street engines, which were made by Mort's Dock Engineering Co., and designed by the speaker (Mr. Selfe), which were fairly worked to death before removal.

It is undoubtedly true, as laid down by Herbert Spencer, that we are all more or less actuated by unconscious bias, and even one who, like the speaker, is not interested in any particular type, may have predilections apart from convictions based on indisputable tests. But unfortunately, in these commercial days, when the business aspect of an engineering installation often overshadows the professional and technical one, the merits of special types are often advocated by skilled salesmen; and it behoves the innocent man, who is merely a technical expert, to be on his guard when the specious advocacy of any particular machine, whether in print or by word of mouth, is put before him.

So far it seems certain that the author of the paper is quite correct when he places the multiple expansion rotative pumping engine at the head of the list for steam con-

[1] Mr. Furniss explained in his reply that the Spottiswoode engines were not of the differential type, but were triple expansion inverted marine type.—N.S.

sumption and permanent efficiency. Next to that comes the horizontal cross-over compound, such as the engine at the Newton Waterworks in America, tested in 1892. In this the pump horse power indicated was ·958 of the engine horse power, and the steam consumed per HP. hour 15·8 lbs. In the Worthington high duty steam pumps at Hampton—recorded by Mr. Mair in the Proceedings of the Institute Civil Engineers, London—the pump HP was only ·849 of the engine power, shewing 10% more loss than the Newton engine, probably through having the compensating cylinders instead of being a rotative pump.

A Hathorn-Davey pump described in a pamphlet issued by the makers had an efficiency of only ·7805, and a steam consumption of 22 lbs., which goes to show that our Melbourne neighbours must have made a marvellous improvement on the originators of the differential system if the figures given by the author are absolutely reliable. (See foot note page XLI.)

The illustrations given by the author of compound centrifugal pumps, were especially interesting to him (Mr. Selfe) because it was not so many years since—before this same Society—he had proposed to set such centrifugal pumps in series, and then met with nothing but unsympathetic discouragement of the idea. The enormous waste of power which is indicated in the results of the various centrifugal sewerage stations is no doubt warranted by other economies, and it is too often lost sight of, that coal consumption is only one charge against a pumping station. No doubt the configuration and levels of Sydney, as well as the solid rock on which it stands, is responsible for the great number of small stations installed for low level pumping, and we have here nothing analogous to the Abbey Mills or Crossness pumping stations of England's metropolis or even to the small substations of London, such as that at

Battersea. If such had been the case, and it had also been possible to remodel the old Botany engines, converting them to triple expansion, then possibly an efficiency at least double of the average now reached in our Sydney sewage pumping might have been attained. It is rather a pity that the author left out all reference to the Farcot (French) type of pumping engine, which is very economical in first cost, owing to the high piston speeds possible; in fact there are records up to 500 feet per minute, and the Botany temporary pump designed by him and made by the Atlas Engineering Co., was run up to 360 f.p.m. quite smoothly. The author's figures for the old Botany engines appear to be much too favourable, they were reported upon by him (the speaker) in 1880, and found then to give an average duty of only 24·07 millions. Of course that is assuming that all the coal paid for was utilised by them. At the same time the locally made Crown Street engines were more than twice as efficient with a duty of 62 millions. Unfortunately the records of the Farcot locally made temporary engines at Botany were hurriedly taken, but they showed about twice the efficiency—although non-condensing—as the permanent condensing engines did. This was largely due of course to the higher pressure of steam and the expansion of same in a compound engine giving a very mild exhaust to the atmosphere.

The diagram given by the author illustrating the water supply of Sydney, and the percentage of "gravitation" and "pumped" water is very interesting, because it shows the futility of going abroad for advice from an engineer altogether unacquainted with the country, when there are plenty of local engineers better seized with local conditions. Although one million gallons a day was raised to Paddington in 1876, Mr. Clarke, in his report on the City Water Supply only allowed for Crown Street station pumping $1\frac{1}{2}$ million

gallons a day altogether out of 18 millions provided for, and that although the Waverley and Woollahra reservoirs were already reckoned with. The author's diagram shows that over 60% of the supply is now pumped above Crown Street, and that for over twenty years nearly 50% of the total supply has had to be so raised. Thus the contentions of the advocates of a high level scheme thirty years ago, of which the late James Manning was such a conspicuous advocate, have been fully borne out. Let us hope many here will yet live to see a direct gravitation supply from the Cataract or similar high gathering ground to the higher levels of Sydney.

In concluding, Mr. Selfe said that if the members were not tired, he would direct attention to another illustration of the marvellous development which had taken place in the city's requirements. From an old table found among his papers showing the yards of pipes laid and taken up in twenty-one years, it appears that in the year 1857 nothing larger than a 6 inch main was laid, the other sizes being 3 and 4 inches; up to 1878 the largest main was 30 inches.

The whole history of the water supply of Sydney shows that we cannot look too far ahead, and this is a great question for the future. Is it to be gravitation for the high levels or an entirely new pumping station? If the latter is adopted, then it should be of the most approved and economic type and carried out in such a way as to be a credit to the city. Let us hope it will not be designed to suit the standards of any one particular maker but that it will embody the best features of them all. If we can make our locomotives and marine engines, surely we can make our pumping engines, also it must be a matter of gratification to all connected with our Society that locally made centrifugal pumps appear to have eclipsed in efficiency any yet tested here of foreign or British manufacture. Such

practical papers as this of Mr. Furniss afford much scope for discussion, and it is to be hoped kindred subjects may be brought forward to keep up interest in the Section.

After Mr. Furniss had replied, Mr. Selfe apologised for having understood that the Spottiswoode engines were "differential" and for the remarks based upon the mistake.

Mr. JAMES SHIRRA said that he had not studied the paper very minutely, but there were a lot of points in the lecture that had not been referred to in the abstract. One thing he wanted to know was, how was the duty of these pumps measured in the tests? Was it determined simply by a consideration of the number of pounds of water lifted and the number of feet it was raised? Duty as arrived at merely by a consideration of the number of foot pounds was not by any means always a true indication of the working power of the pump. Many other things had to be taken into consideration. In connection with the figures shown on the diagrams, he would like to know whether the power expended in the suctional column had been put in the head or not? (Mr. Smail, "That was included in the tests by which the figures were arrived at.") Mr. Shirra continuing, said he thought better results would have been achieved in the trials if a pressure gauge had been put in the delivery pipe close to the pump. (Mr. Smail, "That was done.")

Mr. Selfe, "Was the duty taken from actual pressure?"

Mr. Smail, "Yes, the pressure due to friction etc., was taken into account as well as the actual weight or volume of water delivered."

Mr. Shirra, continuing, said that he had noticed in the abstract, that of the three pumps at the Marrickville Stormwater Pumping Station, there were two of local manufacture which were somewhat more efficient than the

imported pump, but the latter ceased to suck sooner than the others. It had not been explained why this should be. The locally manufactured pump discharged more water with more efficiency, but it required a greater head over the mouth of the suction pipe. That could in his opinion be very easily remedied. If a pipe were parallel (that is, of the same girth throughout), the water had to get its velocity suddenly. Water by its composition was opposed to this sudden acquirement of speed. This trouble could be overcome by giving the pipe a bell-shaped mouth. In the abstract it had also been stated that the constructors of centrifugal pumps appeared to have treated the question of end thrust in a lax manner. He understood that the best centrifugal pumps had suction pipes on both sides of the spindle; if on one side only it would mean that there would be a great weight of water pressing on that side. Was the end thrust due to the impact of the running water forcing the pump to one side? More information was wanted about end thrust.

The figures in connection with economy of steam consumption also required carefully looking into. From the diagram the pumps would seem to be very efficient, but the coal bill showed that they were not. This required explanation. Had the wetness of the steam anything to do with it or was it due to condensation in the cylinders? He believed that in the Hathorn Davey pump engine there was a great danger of loss of steam through leakage, especially through working with wet steam. One of the great problems of engineers was to get a tight slide valve. Had any experiments been made to explain the missing steam shown in the diagrams? The diagrams were very good to look at. Missing steam had been attributed to condensation and evaporation in the cylinders, but it could hardly all be due to those causes.

Mr. KILBURN SCOTT said that when he first came to Sydney one of the things that impressed him was the excellent sewerage system of the city. He had also been further impressed by making visits and seeing that the Water and Sewerage Board was keeping right up to date in applying electricity to pumping machinery and using centrifugal pumps. He was not sure that the imported pumps were running at the critical speed at which they were supposed to run. If you ran a centrifugal pump at any other than just the right speed you were certain to get lower efficiency. Much trouble was frequently experienced in mining work on this account. He had himself had much trouble in this way on one occasion when using three phase motors for pump working. With a direct current motor the pumps could be worked much more advantageously. (Mr. Smail, "In our tests speed was perfectly satisfactory.") Mr. Kilburn Scott, continuing, said, that, to his mind, the centrifugal pump was the pump of the future. It required so little attention and was so easy to start and stop, and it had besides many other advantages.

Mr. FURNISS here stated that his figures were obtained from a paper published in England and recently read before the Institute of Water Works Engineers. The minimum cost figures were however taken from an actual trial, extending over six months, of a triple expansion set, very similar to those treated of in the paper,—Hathorn Davey's £36 was the relative figure for electricity in the same work. Mr. Kilburn Scott—"Do they both include labour." (Mr. Furniss, "Yes."

Mr. Kilburn Scott, continuing, said, that the only way in which he could imagine the figure of £36 to have been arrived at as the cost of electrical working per annum was as illustrated in the following table, which he put on the board:

$$\frac{\overset{a}{746 \times 8760 \times 1{\cdot}33}}{1{,}000 \times 240.} = £36:7:7$$

They were, he said, selling electrical power for similar purposes in Lancashire at ½d per B.T.U., while in some places water generated electricity could be obtained at the rate of £2 15s per HP. per year, which was much cheaper than steam generated power. Even where the electrical power was obtained entirely by steam it was far under ½d. per B.T.U. in some places. (Mr. Smail here stated that the Board had to pay the City Council 1d. per unit for electricity supplied to Crown Street for pumping purposes.) Mr. Kilburn Scott considered this price as excessive, and said that if the Board could give the City Council a day load of half year, say 4,000 hours a year, they ought to be able to supply the necessary power at a much lower rate and get profit out of it. In Switzerland, he said, water generated electrical power was obtainable at the rate of £1 2s. 6d. per HP. per year. Power from Niagara was obtainable in Baltimore at about £4 per HP. per year, and the price of electricity in some places was as low as ⅓d. per unit. (Mr. Selfe, "If they have got such wonderful engines to generate electrical power, at such cheap rates, what is the necessity for converting the power in those engines into a current, running it perhaps for scores of miles and then re-converting it again into motor power, when the engine itself could be bodily shifted into the pumping station?") Mr. Kilburn Scott, "The units used in individual pumping stations are in the nature of about 7,000 or 8,000 HP. per year, which would not profitably employ these large engines. It is a question of the big man being able to outsell the little man."

Mr. PRICE said that he had not the privilege of hearing the paper read, but he could see by the abstract printed that it had been a very valuable paper indeed as regarded

information. He felt more inclined to criticise the criticisers than the paper. He had represented the contractors at the tests of the Hathorn-Davey pumping engines both at Marrickville and at Spottiswoode, Victoria, and could vouch for the accuracy of the figures. They had been carefully checked at Marrickville, by the representatives of the Board of Water Supply and Sewerage, Sydney, and at Spottiswood by the representatives of the Melbourne Board of Works. Mr. Selfe was under a misapprehension as regarded the type of engine in use at Spottiswoode. The engine in question was a triple expansion vertical engine, operating direct on to the pumps, as is the practice of high class marine engines, and of course, very high efficiency indeed could be expected from such a pump. As a matter of fact the steam consumption measured per indicated HP. was $11\frac{1}{2}$ pounds, and as the same results exactly had been obtained both at Odessa and at Leeds, it could be seen that there was nothing out of the common in this for that particular type of pump. The results at Marrickville had not been so good because the engine there is a compound type, and had to be run at a lower speed being too large for its work; when the engines were run at full speed there was not sufficient work and the motion was intermittent. It was not until Mr. Furniss hit upon the idea of throttling the delivery pipe that the difficulty thus caused was overcome. He (Mr. Price), believed that there was a certain amount of storage under the Hathorn-Davey system. The discs to which the connecting rods and the plunger were attached must, he thought, store up a certain amount of energy derived from the difference in the motions and speeds. This energy was, he thought, partly instrumental in producing the high rate of expansion observable in Hathorn-Davey pumps as compared with Worthingtons, where there is air storage. When dealing with air expanding or contracting there must be a certain amount of loss

of heat through radiation, and of course a decrease in the temperature through the compression of the air; consequently there was a certain amount of loss in such a system of storage. He was of opinion that steam power at present was cheaper than electricity for pumping purposes, the figures for each according to his reading would be somewhere in the nature of .26d. per HP. per hour for dry steam, including labour and everything else, and .35d. for electricity. He quite appreciated Mr. Selfe's point as regards turning the steam into electricity and then back again into pumping power, which practice he stated would only be economical in the case of very large generating stations. Even then, he said that the cost of transmitting the energy would go a long way towards eating up the economy thus gained.

Mr. J. M. SMAIL said that the paper had been cut down to such an extent as to leave it practically without any connecting links. He complimented the writer on his valuable paper, because it was papers of that description that were useful, not so much to the older, but to the younger members of the Section. One of the points he noticed about the Engineering Section was that they laid themselves out specially for the younger members of the profession. The old Botany engines referred to by Mr. Selfe were of the old low pressure type, Lancashire boilers, pressure about 40 lbs., but, as a type of British built engines they compared in solidity and good work with any engines that we had in later days. The next type introduced was he believed, an engine designed by Mr. Norman Selfe and built by Mort's Dock Engineering Co. The first of these was a very elaborate engine, but it outlived its usefulness. Then we had the modern type of Worthington pump, Nos. 1 and 2, which also did great credit to its builders, particularly on account of the small cost of upkeep entailed,

which he believed was as low as that of any pumping engine in the world doing the same amount of work. Latterly we have had the Watt engine introduced at Ryde Pumping Station, not altogether superseding the old pumps, but as an improvement. These pumps however, did not maintain the high reputation for duty in actual work which they achieved at the trial; they nevertheless did very good work. Then came the newer type of the turbo centrifugal pump, and marked, he thought, the line of divergence in one important particular between the pumping stations of the past and those of the future—their economy of space. One of these pumps raised water to a higher elevation than any other south of the Line, or indeed, so far as his knowledge extended, in the world. So far these pumps had worked well, but from an engineering standpoint, one important factor had to be looked to, that was that the ratepayers did not pay too much, and that the machinery chosen for works of this nature should combine the maximum of efficiency with the minimum of cost so far as was consistent. It would be absurd to give any opinion as to the efficiency of these pumps after only one or two months of running, because the only opportunity of testing them had occurred when the reservoir at Wahroonga was empty. With regard to the sewage pumps, Mr. Smail did not want to say anything about the original engines, but he was very glad to be able to say that the Board had adopted a sensible view by simply taking them out and placing them on the scrap heap; that was all that could now be done with them, although their workmanship was, he believed, unsurpassed —it was the type and design of the pump that were at fault. The next pump introduced was he thought the Gwynne. Then Mr. Zollner came along with his own pump, which appeared very well in the schedule, still experience had proved many things about pumping machinery for that gentleman to learn, especially in connection with the thrust.

Then we came to the Gwynne and Reynold's pumps at Crown Street. These were coupled to an electric motor, and as a matter of fact, the Reynolds pump was able to do the whole of the work, the Gwynne being merely used as a standby.

With regard to obtaining electrical power for pumping purposes, the Water and Sewerage Board were at present in a very bad position. Their current was obtained from the City Council at a cost of 1d. per unit and it could only be got at a light load. The pumping had to be arranged to suit the load. A current was also received for some work from the Railway Commissioners, but the Board had absolutely no control over the production of the power either by the City Council or by the Railway Commissioners. If the power stations broke down as they might do, the Board, having no current of its own, would have to permit the sewage to go into the harbour where it went before. Fortunately in the event of such happening we have still got pumps at Crown Street which could be worked. In his opinion the Board should be very chary in extending the application of electrical power for either water supply or sewerage purposes unless they had their own generating station. He thought it quite possible that, in the event of an extension of their operations, the Board would be able to generate their own electrical power at a much cheaper rate than that now paid to either the City Council or the Railway Commissioners. In the trial of the Parsons' turbine pumps, the steam consumption per HP. per hour was found to be 29·74 lb. as against the guaranteed 37 lbs., so that was less than we expected.

Mr. T. H. HOUGHTON, M. Inst. C.E.—The paper which was read at our previous meeting by Mr. J. F. Furniss brings out strongly the various changes which have been made in pumping machinery during the last twenty years, in which

time we have seen the centrifugal pump advance from being only an expensive steam eater capable of raising large quantities of water to a moderate height into an economical pump, and also suitable for practically unlimited heights, it only needing multiplication of the number of pumps in series to give any height required for the delivery of water or other fluid, and the example of a high lift single stage pump at Crown Street station and the series pump at Ryde show that those responsible for the water supply of Sydney are keeping up to date with the most modern types of plants. Although in first cost centrifugal pumping machinery has a great advantage, yet I cannot think that they will ever have the life of good compound beam pumping engines. I understand that the compound beam pumping engines designed by the late Dr. Pole, F.R.S., and built by Simpson & Co., in 1851, are still working at the Lambeth and Chelsea Waterworks at Surbiton, these engines with their 8 feet stroke, making 16 revolutions per minute, often working for two months without a stop, have I believe, proved themselves less costly for maintenance than any other type of pumping engines. The solid foundations, direct lines of thrust and solidity of construction, ensuring economy in maintenance, and as regards fuel consumption, even when the low boiler pressure (40 lbs.) at which they have worked is considered, they have given a highly satisfactory result.

Subsequent to 1851 many other beam engines were built by the various makers for pumping water, and with the increase in pressure the steam consumption per indicated horse power was reduced very considerably. A beam engine, built in 1885, with only 60 lbs. boiler pressure, used as little as 15·12 lbs. of dry saturated steam per indicated horse power per hour. Earlier than that, in 1881 a beam pumping engine had been constructed using 14·84 lbs. of

dry saturated steam per indicated horse power. The efficiency of these beam engines when working against a head of 150 to 200 feet is high, being about 84%, so that to compare favourably with the older types of pumping engines a centrifugal pumping plant must have a high efficiency, as must also the motor, whether it be steam, electricity, or gas that drives it. The cost of beam engines and the necessary foundations and buildings to house them is much greater than that of high speed machinery of the same capacity, so that for a plant running intermittently, the annual charge for interest will prove whether the advantage of decreased cost of maintenance and depreciation will not enable them to hold their own with high speed pumps. Many horizontal pumping engines have been built with mechanically controlled pump valves, the engines being fitted with the most economical type of valve gear running at high speeds and being such as to ensure the efficient use of the steam admitted. These have given good results and although somewhat costly, yet when the maintenance and fuel consumption are capitalised, it will be found that they show very favourably; as the author points out it is not only fuel consumption which has to be considered, but the whole question from the handling of coal to the disposal of the ashes, and to this should be added the cost of maintenance, depreciation and supervision.

The author calls attention to the difficulty of balancing the impellers of centrifugal pumps; I suppose he refers to single suction pumps, as on those pumps the suction inlets are equal on each side I do not see how it is possible for any serious end thrust to occur. In many of the pumps built some years ago we bored holes in the side of the impeller to admit water from the impeller into the space between it and the side of the pump in order to balance the end thrust. This is very similar to what he describes

as a balance piston, except that it was not a piston but a balancing ring. Many of the vertical centrifugal pumps with which I had to do years ago, had the thrust also taken up by collars on the shaft, which proved for moderate pressure a very satisfactory method. Some makers used what was termed an onion bearing, which gave greater flexibility, but which required to be made very large to afford the surface necessary. With pumping machinery where the head is known and with steady steam pressure, it does not appear to be an advantage to provide automatic expansion and the refinements necessary, as the work done is generally a steady one, such variations as occur in it being at definite times and always known beforehand, so that expansion valves which can be varied by hand will answer as satisfactorily as the more expensive automatic gear. The engine to which Mr. Furniss refers at Spottiswoode as being so very economical, is fitted with a very elaborate automatic expansion gear which can only add to the friction and the cost. The work it has to do being practically constant, the only variation in the pressure in the delivery main is due to the number of engines working into it and their speed.

In low lift pumping machinery, the percentage of indicated horse power in the steam cylinders, utilised as pump horse power, is invariably low, so that it is not fair altogether to criticise the steam end of all pumping engines by the steam consumption per pump horse power per hour, for with the same steam end connected to a pump working against the greater pressure, it will be found that the efficiency is much higher for the friction of plungers and glands, and the resistance of the pump valves is nearly constant, being independent of the pressure, and of course at low heads form a greater proportion of the total head than at higher pressures.

Many papers of descriptions of the pumping plants have been published in the Proceedings of the Institution of Civil Engineers and other scientific bodies, and I think it will be interesting to members if they will look at Vol. 78, where they will see a paper on "The comparative merits of vertical and horizontal engines and rotative beam engines for pumping," by the late W. E. Rich, M. Inst. C.E., and compare some of the engines illustrated in that paper with, for instance, the centrifugal pumping engines at Ryde and Crown Street, they will then have a good idea how much recent investigations and experiments have simplified the construction, reduced the cost and the spaces occupied; but will the new types last as long, will not the wear of guide blades soon impair the efficiency of the pumps and to a large extent counterbalance other advantages?

The table of steam consumption and piston speed given in the paper could I think, be further elaborated, the old Botany beam engines gave an excellent result if they only required 30 lbs. of steam per pump horse power per hour, although it heads the list of steam consumption, yet for a single cylinder type the result is good. I am sorry to see in the paper no reference to a very interesting engine which was at Botany, designed by Mr. Selfe, I think, somewhere about 1883 or 1884. I saw the engine at work for some days, and although the steam part was not of the highest class, having been, I know, the best that Mr. Selfe could get in the short time available, yet the pump had every point of the more recent high speed horizontal pumps, and I think it is a pity that some use could not have been found for it with a more economical type of engine for the supply of some of the outlying districts of Sydney. The data which the author has given as to quantity of water pumped and the machinery in use for the supply of Sydney, and also the various systems of raising sewage, will I am

sure be most interesting to members, and if the data obtained on tests of the modern plants, both at Ryde and Crown Street could be made available, the tests being conducted on the lines laid down for testing pumping machinery they would afford comparison between steam driven and electric driven pumps of large power and be of great advantage to the engineering profession.

Mr. Furniss (in reply) said he was in a very unfortunate position in one respect in that he would hardly have known his paper as it came from the printer, so much was it cut down, except for the diagrams. The usefulness of the paper had been, he thought, to a very great extent reduced on this account. However, notwithstanding the small number present, he was very pleased with the interest shown by those who had spoken. They had dealt with the paper exhaustively and time would compel him to be comparatively brief in his reply. He had to clear away some misapprehensions which arose in the minds of members, due, in many instances to their experience having been quite foreign to pumping practice. One was in connection with the practice which applied to pumping engines with regard to the measuring of their duty and the preparation of figures illustrating that duty.

In proceeding to review the remarks, he would like to explain one thing. One gentleman spoke of the relative values or efficiencies of centrifugal pumps and their speeds. He had dealt fully with that point in his paper, where he had clearly pointed out that there was a speed at which a centrifugal pump should be run, and that speed was certainly more effectually arrived at by actual trial than by any figures that could be supplied. No gauge on the discharge pipe would give any indication of the want of efficiency of a pump; he meant that, after the pump had been fitted up and had acquired the peripheral speed due

to the conditions under which she was running, then no increase of speed in working would show any increase of pressure in the column. That had been brought home to him by actual experience during the last two or three years. He regretted that he did not mention Mr. Selfe's pump at Botany. He had run this pump on that occasion when they had to fall back on the old Botany supply when the 48 inch main broke many years ago. He regretted also that he had not spoken of the high speed engines referred to by Mr. Houghton, but that was on account of the length of the paper. He could speak with authority on the subject of the relative value of published statements and the actual facts as determined by experience, as it had for many years been his practice to have trials periodically and to compare the results of same with the results of the test runs.

Mr. Selfe had remarked that the intermittent running of pumps should not be allowed to influence the running costs, because in trials the extra expense due to this irregularity should be eliminated in the figures resulting. This was already done. In trials, runs of 12 hours were taken where possible; then long runs were taken, all extraneous charges being eliminated. Mr. Selfe had also said that there was no storage of energy in the Hathorn-Davey pump. But there was in this pump what practically amounted to a storage of energy. Storage of energy in the Worthington pump was only a storage from one end stroke to the other end stroke, but in the Hathorn-Davey the storage was arrived at by a geometrical and mechanical arrangement. The Hathorn-Davey was a non-rotative engine. (Mr. Furniss then indicated by illustration on the blackboard, how the storage was arrived at in the Hathorn-Davey type. A slide showing indicator cards from four typical pumping engines in Australia was also exhibited in connection with which Mr. Furniss made the following remarks:) This,

(indicating) No. 1 is the card of No. 1 Worthington engine at Crown Street, this No. 2, is that of the semi-rotative Hathorn-Davey pump at Marrickville; this No. 3, belongs to the Hathorn-Davey rotative triple expansion pump at Spottiswoode, of which the steam consumption is disputed; and this No. 4, is the card of the compound rotative engine, surface condensing, at Ryde Pumping Station. Now a diagram is a most misleading thing unless it is verified by actual investigation of all the points which it displays. Notwithstanding that this Worthington engine carries its steam for four-tenths of its stroke, it is 10% more economical than this Watt engine, which cuts off at less than one-tenth of its stroke. The duty of this Worthington engine is 86 millions calculated on a proper daily work basis; the duty of this Watt engine is not more than 63 millions. This is the engine Mr. Smail spoke of as a "Watt" engine. You would naturally suppose that the Worthington using more steam would be less economical than this; this however is not so. While the Watt engine carries 100 pounds pressure in the boiler and 97 pounds initial pressure in the cylinder, the Worthington engine carries 100 pounds pressure in the boiler, 97 in the engine room and only 66 pounds initial pressure on card. The difference in the volume of steam at a pressure of 97 pounds and at a pressure of 66 pounds would explain the difference in the cards between these two engines, taking into consideration the different circumstances surrounding each. In the case of the Worthington engine above referred to, the steam was wire drawn, and yet notwithstanding this, it carried a good deal of the temperature due to the higher pressure and would carry more had it quicker means of reaching its work instead of having to traverse several pipes in a roundabout way, losing heat and increasing condensation in the process.

(A slide showing the non-rotative engine at Marrickville Pumping Station was now introduced.)

In the stroke of this engine the steam was carried for about $2\frac{1}{2}$ tenths. Mr. Furniss also explained the provision made for "cushioning" in this engine, and stated that the lack of economy in the machine was due to the slow speed of the piston. The maker's specification had stipulated that the piston speed should be as low as 4 strokes per minute and not higher than 10 strokes per minute, which latter speed would only amount to 60 feet per minute. In the trial the speed had to be increased largely in order to obtain the contract duty. The steam condensation at the trial was 13% and a duty of 69 million pounds was shown. The contract duty was 60, and since the trial the engine had produced a duty as high as 70 millions. One feature about this engine was that, while its economy was satisfactory, it was about as true a weighing machine as it was possible to construct, that was in connection with *its* measuring of its load; true the head load was always constant, but the suction load was a varying one.

The slide showing the Spottiswoode sectional elevation was the wonderful engine in Melbourne that had brought steam consumption down to 13·65 pounds per pump HP. Notwithstanding this, the mechanical efficiency was not so great as might be expected. The mechanical efficiency, as he took it was the indicated HP. as calculated from the card set against the actual work done by the engine. Mr. Selfe had been in doubt as to how this was arrived at. It was a simple calculation, and the only trouble about truly arriving at it was that you had to be positive that the cubical contents of the pump were a true measure of the work done. This could only be positively arrived at by having a measured tank for the pump to fill. The opportunity of verifying these tests by actual trial was taken by the officers of the Water and Sewerage Board when measured reservoirs happened to be empty for cleaning

purposes. The reservoirs were filled at night when there was no outflow, and the contents of the reservoirs were then set down as the work done. That was the method adopted by Mr. Smail in his recent trials. The results of these trials showed a duty of 66·68 million foot pounds per thousand pounds of steam for the turbo engines, very good work. These trials were actual facts, he had seen them himself. Mr. Selfe had been talking of the work necessary to overcome the resistance of the column, in connection with the Marrickville pump. This pump had a bellmouth suction. The total head was in this case only 45 feet, measured from the valve boxes to the point of discharge, the wells being 25 feet deep. That was why this particular engine could not produce the same wonderful results as the other two, notwithstanding its many splendid arrangements.

Referring to the wonderful Spottiswoode pump that has proved so economical, Mr. Furniss said that the surfaces of the piston and the internal surfaces of the cylinder were perfect planes. There was therefore very little clearance and great economy of steam consumption was thus obtained. He then described how thoroughly the steam was utilised in this engine, which contained the simplest valve gear he had ever seen; they were semi-rotative valves, very similar to those of the Worthington pump, and passed right through chambers in the covers independently of the cylinders altogether. The clearance of this engine also was very small indeed, and there was very little loss. There were no large valve chests to fill with steam because the steam passed direct to cover. There were two valves, one steam and one exhaust, and the valve gear by which they were operated consisted merely of bell cranks on the end of the spindles; these valves were very easily governed by positive cut off gear.

(Mr. Selfe here explained that his remarks about the Spottiswood pumps had been made under a misapprehension.

He had understood that they were Hathorn-Davey pumps of the differential type not triple expansion pumps.)

Mr. Furniss then went on to explain the similarity of the results attained by the different methods of storing energy in connection with the Worthington and Hathorn-Davey pumps respectively. The Worthington pump stored up energy first and then gave it out so that this pump was considerably quicker than others which had to be gradually worked up to their full speed. The Worthington could start right off at full head load. Mr. Houghton in speaking of end thrusts had stated that he could not understand how it could exist or how it was that the makers of the pump did not make provision to counteract it, and that it certainly could not exist in a bifurcated suction pump. The centrifugal pump in connection with which the end thrust had caused trouble, was not a bifurcated suction pump. It was the first high duty centrifugal pump that was introduced into New South Wales. This pump depended for its efficiency on the form of the impeller, the case of which was so arranged that it had apertures which allowed the water to pass through. Actual practice had proved that it was deficient in means for counteracting end thrust. Mr. Smail, in his comments, had remarked "that the centrifugal pumps were anything but perfect in the measures adopted for the prevention of end thrust." Mr. Smail had had to make extensive provision to overcome this difficulty, and several arrangements for this purpose had been perfected in the department presided over by Mr. Smail.

The makers of the Reynolds pump installed at Menangle did realise that there would be end thrust. The specifications for the contract had included provision to overcome the difficulty. They had put a marine type thrust block on, but it was so small, that it was found that it would not overcome the resistance. In this case the pipe led along

to a river and the suction head was practically about 10 feet, while the delivery head was 230 feet. The pump had been started with a load measured practically by the 10 feet suction head. It was then gradually speeded up to the essential speed necessary, being worked by a 245 HP. electric motor. During the time of getting up speed it had been charging a long line of 22 inch main up a mountain side, and it was a long time before the head load was distributed on both sides of the impeller to overcome the thrust. The builders had stated that the magnetic pull should be availed of to overcome the thrust, but this did not work out in practice.

As it was getting very late, Mr. Furniss had, rather abruptly, to conclude his remarks; he thanked those present for the interest they had taken in his paper. Much of the matter it contained had, he said, been prepared in Mr. Smail's department of the Water and Sewerage Board. He did not claim that much originality was shown in it, but it had been the outcome of the pursuance for years of a study that was very interesting to him, owing to the fact that he was a pumping engineer.

The President (Mr. Keele) said that it was a great pity there had been so few present, but those who had attended had compensated for this by the great interest taken in the subject, and the discussion had been very instructive to all. One duty now remained to him, to heartily thank Mr. Furniss for his very interesting paper, and for the instructive discussion it had led to. A vote of thanks had been accorded to the lecturer on the occasion of the reading of the paper, but he was sure that those present would only be too glad to renew their thanks again.

This was carried by acclamation and the proceedings terminated.

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